Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

FIVE DOLLARS A YEAR

APRIL 1955

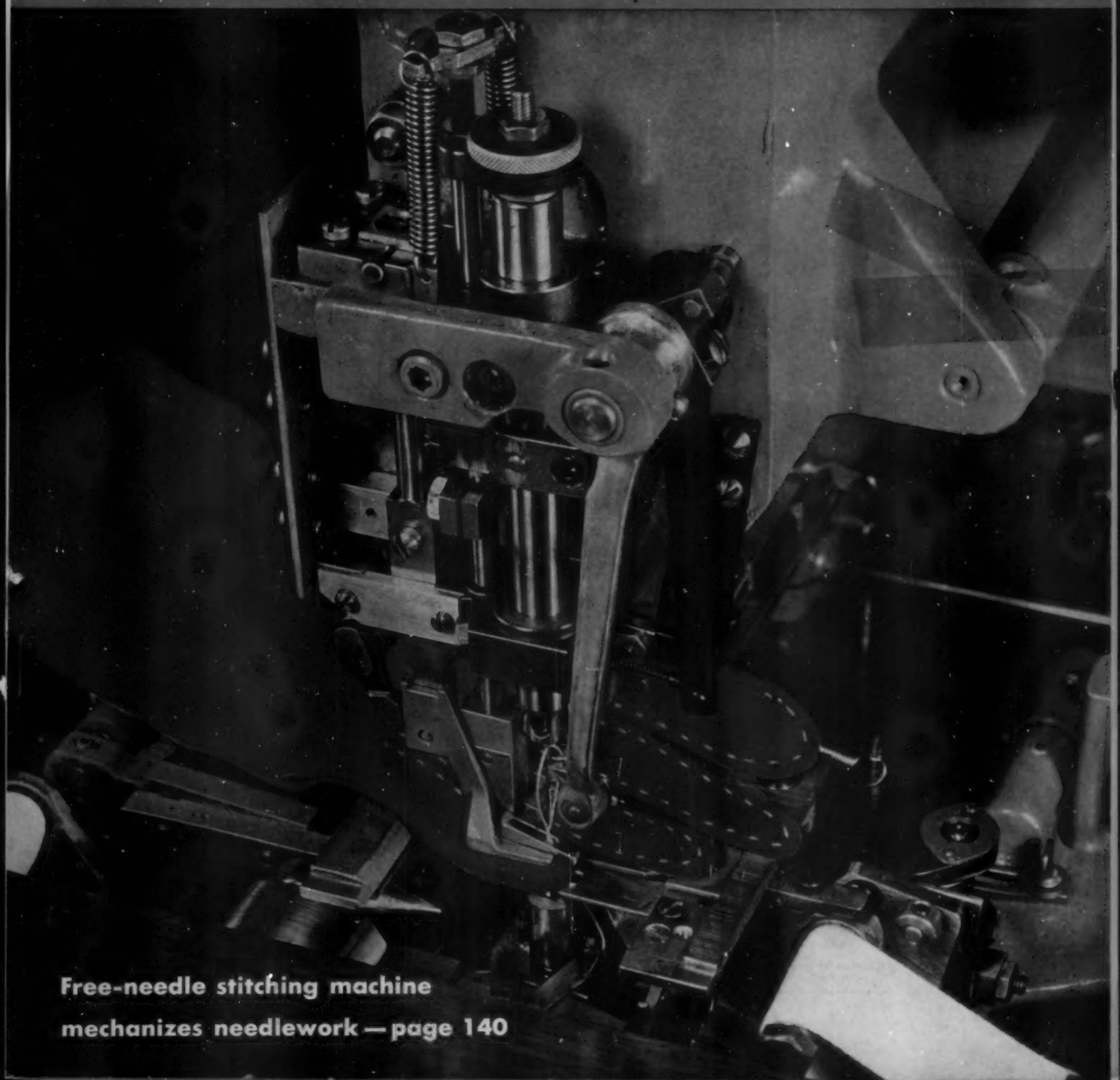
Flow Analysis for

HYDRAULIC CONTROL

Titanium Bolt Strength

One-Side Spot Welding

Phosphate Undercoats



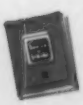
Free-needle stitching machine mechanizes needlework — page 140

Cessna uses SIRVENE

PRECISION MOLDING SOLVES PUMP PROBLEM

It's licked: the problem of low efficiency in gear pumps at 1500 psi caused by hydraulic oil by-passing the gear teeth. Working from Cessna's unique design, C/R developed this Sirvene (synthetic rubber) gasket seal that equalizes the pressure of its effective areas with that within the gear chambers. It seals effectively at 1500 psi with temperatures up to 170° F., and would be suitable for pressures and temperatures above those encountered in operation. The extremely close tolerances to which this Sirvene part is made are vital to the pump's greatly increased efficiency and service life.

C/R SIRVENE
SCIENTIFICALLY COMPOUNDED ELASTOMERS



WHENEVER you need a flexible molded part, produced in quantity with the utmost precision, you need C/R Sirvene. Write us for your copy of "Engineering with Sirvene."

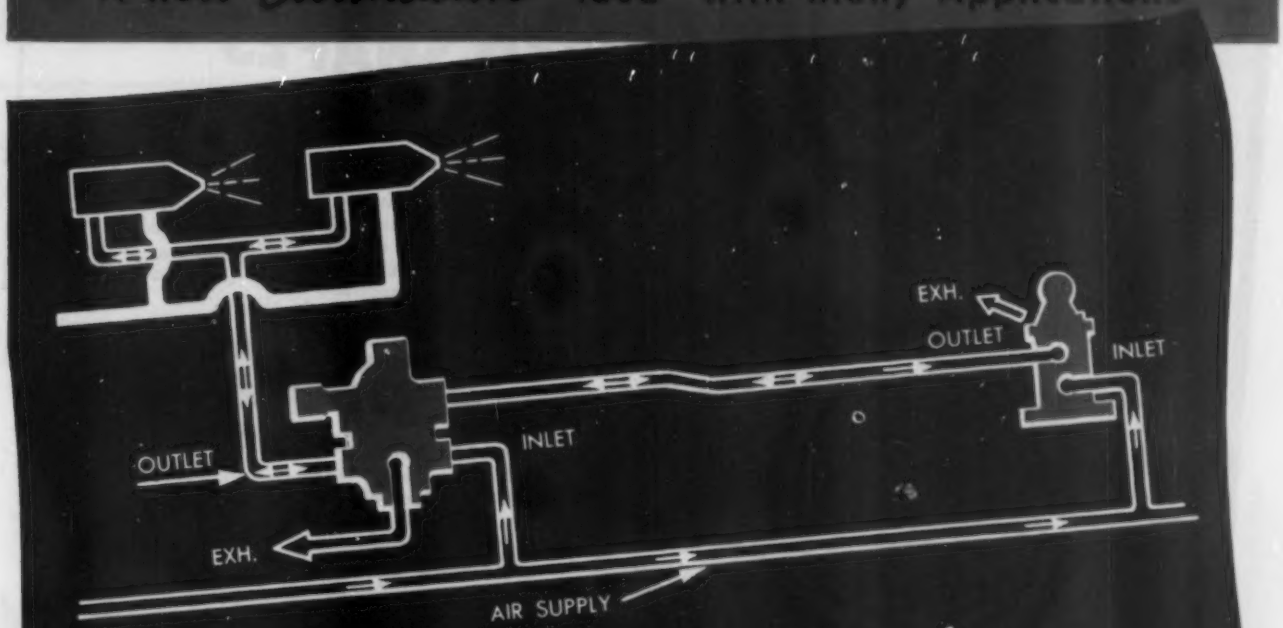
CHICAGO RAWHIDE MANUFACTURING COMPANY

1301 Elston Avenue SIRVENE DIVISION Chicago 22, Illinois

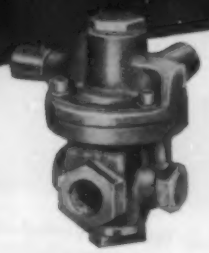
Other **C/R** *products*

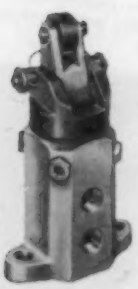
OIL SEALS: Shaft and end face seals for all types of lubricant retention and dirt exclusion • CONPOR: Controlled porosity mechanical leather packings and other sealing products • SIRVIS: Mechanical leather boots, gaskets, packings and related products.

A Ross *Airmation* Idea—with Many Applications



Sprays drawing compound with every press operation





- **Designed for spraying drawing compound on panels before stamping, but adaptable to any application requiring intermittent spraying or air blasting.**
- **Reduces manual work; assures precise quantity of fluid and accurate delivery.**
- **Controlled by Ross Time Delay Sequence Valve which is remotely controlled by Ross Cam Operated Valve which is actuated automatically.**
- **Amount of spray time can be varied by adjusting metering stem on valve.**
- **For assistance in engineering this Airmation idea to your application, contact your nearest Ross Service Engineer. He offers practical creative assistance.**

Ross—The Bridle for Fast, Clean, Economical, Strong, Responsive Air Power

ROSS Control VALVES

Ross OPERATING VALVE COMPANY

114 E. GOLDEN GATE AVENUE • DETROIT 3 • MICHIGAN

Look into
REVERE EXTRUDED SHAPES
—it may pay you as it did Westinghouse

When engineers of the Westinghouse Electric Corporation, East Pittsburgh, Pa., designed an inner-cooled generator rotor, the problem of making the hollow rotor coils arose. It was decided to make these out of two channel sections, butted together. Such channels could be made by milling solid copper bar, but Westinghouse knew how expensive such a process is. Could Revere produce the channels by the extrusion process? We thought we could, and after close collaboration with Westinghouse engineers, the various design and extrusion requirements were finalized. The channels are extruded, drawn, annealed, and then given a final draw.

Generators containing these special rotors are cooled by forcing hydrogen through the inner-cooled conductors at 30 psig. Because the heat is picked up directly from the copper, cooling performance is greatly increased over former designs. As a result, generator output can be approximately doubled without increasing physical size. To put it in other ways, output is increased per pound of generator weight and per pound of fuel.

Extruded shapes can save a great deal of machining time and money, and make new ideas commercially practical. Come to Revere for them in copper and its alloys and aluminum alloys.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

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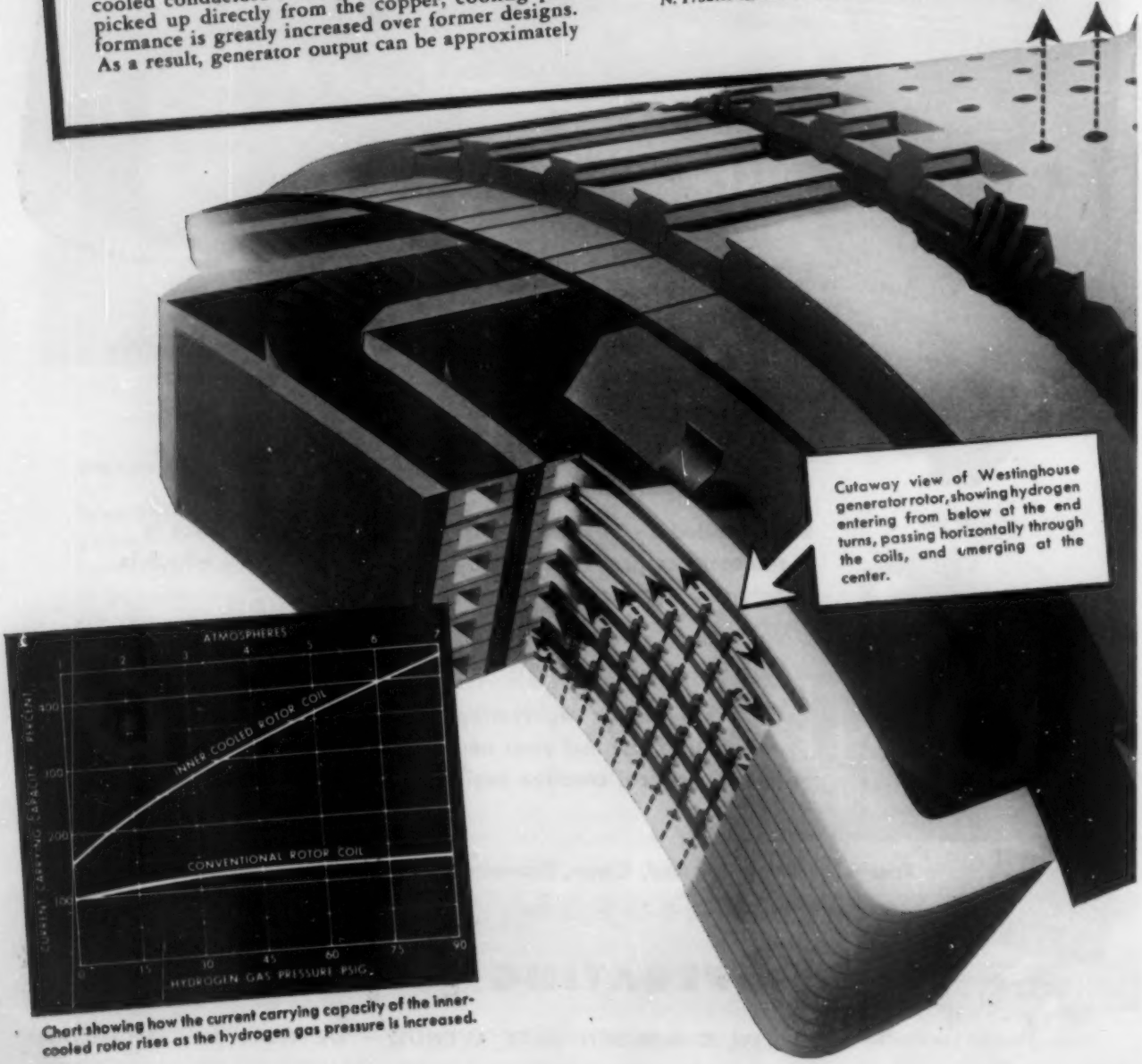
Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.



Cutaway view of Westinghouse generator rotor, showing hydrogen entering from below at the end turns, passing horizontally through the coils, and emerging at the center.

Chart showing how the current carrying capacity of the inner-cooled rotor rises as the hydrogen gas pressure is increased.

Product Engineering

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Strength of Titanium Bolts ..... Joseph Viglione **129**
Results of tests show titanium bolts compare favorably with steel bolts and are superior to aluminum bolts of the same size.

Operating Three-Phase Motors from Single-Phase Supply ..... Irwin B. Galter **134**
Can decrease product cost and increase utility, performance, capacity and life by using low-cost static phase adapters consisting of simple electrical components.

Product Designs **140**
Mechanical hand stitcher has floating needle; Compact motor compressor; Automatic electro-pneumatic drill unit; Economical hand truck assembly.

Response of Dynamic Systems ..... Walter W. Soroka **150**
Superposition technique provides a simplified method of solving problems with complicated force-functions.

Protective Coatings for Electrical Connections ..... Howard B. Gibson **156**
Prevent formation of high-resistance surface films; aid in maintaining low-resistance connections and preventing discoloration.

Theory of Hydraulic Flow Control ..... Nils M. Sverdrup **161**
A detailed analysis of the hydraulic resistance and flow rate of parallel and series circuits and various flow-control components.

Fatigue of Notched Specimens ..... Roy A. Miller **177**
Interpreting K as a strain instead of stress factor permits predicting failures of notched specimens from data on unnotched parts.

Designing for Production—Reducing Waste ..... W. M. Halliday **178**
Seven ways of reducing non-cutting motions in machining.

Spot Welding From One Side—With a Portable Gun ..... C. A. McClean **180**
When to select this inert-gas shielded tungsten-arc process to speed production and reduce costs; how to design for its use.

Phosphate Finishes ..... Norman P. Gentieu **190**
Surface treatments are important for enhanced corrosion resistance and paint bonding. Types of phosphates used and methods of application.

Answers to 17 Ball Bearing Problems **195**
Includes questions on mountings, load and speed capacity, seals and lubrication.

Increasing the Holding Power of Press Fits ..... Richard Hazelett **209**
Set of charts and formulas simplifies design analysis.

Reynolds Number Chart ..... George Loweke **213**
Covers fluids ranging from castor oil to mercury.

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Number of copies printed this issue 33,788

Mallory Rheostats Offer More Ratings... More Performance

THE Mallory line of rheostats, covering ratings from 25 to 500 watts, includes the largest selection of Underwriters' Laboratories approved rheostats on the market. You can be sure of getting the right rating and resistance value for your application . . . without need for "stretching" an undersized unit, or settling for an uneconomical oversized one.

Famous for long, trouble-free service, Mallory rheostats use high-stability ceramic insulation, and are designed for effective ventilation. Precision winding methods developed by Mallory assure superior linearity.

MINIMUM MAINTENANCE. The Mallory hinged contact lets you clean or replace the brush without changing contact pressure. Because the spring does not carry current, overloads cannot cause annealing of the contact spring arm.

VARIABLE PITCH WINDING, by special Mallory techniques, produces tapered windings from a single wire . . . eliminates hot spots and excessive wear at points where wire size changes . . . and reduces rheostat cost. In addition to standard types rated at 25, 50, 75, 100, 150, 225, 300, and 500 watts, Mallory will be glad to engineer special rheostats of single or multi-unit construction for your specific requirements. For complete technical data, write or call Mallory today.

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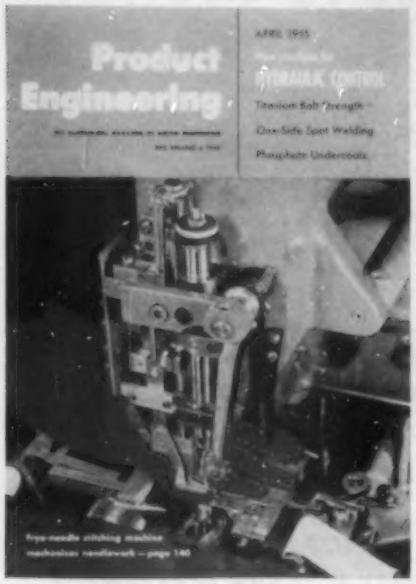

THIS MONTH'S COVER

American needle trades have traditionally depended on skilled hand sewers; it seemed impractical that a machine could do needlework (where needle carries thread through cloth and returns by a different path). This new stitching machine developed by American Machine and Foundry Company does it at 400 stitches a minute using a double-pointed needle with a center eye. See story on page 140.

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Highlights

Current research and developments soon to influence product designs.

PAPER FROM SYNTHETIC FIBERS . . . .

. . . . reportedly up to 10 times stronger than conventional pulp or rag paper, has been successfully produced by the E. I. DuPont DeNemours & Co., Inc. of Wilmington 98, Delaware. Made experimentally from nylon fiber, dacron polyester fiber, and orlon acrylic fiber, the properties of these synthetic materials make the papers resistant to chemical attack, absorb little moisture, and resist the action of mold, bacteria and light. The paper's high strength suggests use in heavy duty bags and for carrying corrosive chemicals. Stability to moisture permits use for maps, tracing papers, and important records and documents. Resistance of these papers to folding is up to 200 times that of conventional papers. In making the paper, the fibers were cut in short lengths, slurried with water, and formed into sheets on a wire screen. The sheets were dried, impregnated with bonding agents, then heated and pressed.

A PROPOSED NUCLEAR POWER PLANT . . . .

. . . . has been designed to use liquid uranium. The study is headed by the Babcock & Wilcox Co., and preliminary work has been started by the Brookhaven National Laboratory. It is believed that such a full scale liquid metal fuel reactor would give the lowest cost electrical energy from atomic fission. In operation, uranium atoms would fission in the graphite core of the reactor. Heat from these atoms would be carried out by a molten alloy of uranium and bismuth. This hot alloy would heat liquid sodium, which would produce steam from water. Advantages of this design: it would breed more uranium fuel; produce high heat without high pressure; simple to build; would permit the continuous and cheap processing of the fuel to remove fission products.

SAVING TIME AND MONEY FOR . . . .

. . . . reinforced plastic molders, a new process by Duralastic Products Co. of 2075 W. Lafayette Blvd., Detroit, Mich., substitutes plastic for metal dies in the production of reinforced plastic prototype products. The process is called "matched plastics molding," and permits designers in polyester reinforced plastic moldings to pre-test new ideas at low costs, and to make any changes in the prototypes before full scale production using expensive metal dies is undertaken. Caution: technique only applicable for polyester reinforced plastics molding. Cannot be used by high pressure molders such as molding phenolics, urea, or melamine.

NICKLE-CLAD STEEL STRIP . . . .

. . . . is being produced by the American Silver Co., 36-07 Prince St., Flushing 54, N. Y., in thicknesses down to 0.003 in., to tolerances as close as ± 0.0001 in., and in widths down to 0.093 in. The new strip has high temperature oxidation resistance, and has been used for lead-in wires for electronic tubes, grid support rods, and other applications where a pure nickel surface is necessary. *(continued on page 7)*

INTERNAL VALVE LEAKAGE COSTS MONEY!

AVERAGE INTERNAL LEAKAGE PER MINUTE 20 OZ.
IN THE MOST WIDELY USED VALVE TYPE.
BASED ON 3/4" VALVE SIZE
AT 2000 PSI OIL PRESSURE
(RATED FLOW 16 GPM)
MAXIMUM INTERNAL LEAKAGE 10 DROPS
IN A BARKSDALE SHEAR-SEAL VALVE
AND ZERO EXTERNAL LEAKAGE.
BASED ON 3/4" VALVE SIZE
AT 3000 PSI OIL PRESSURE
(RATED FLOW 20.5 GPM-
COULD BE AS HIGH AS 42 GPM
WITHOUT DAMAGING EFFECTS)

There is a direct ratio between the amount of leakage in a valve and the expense from it.

Both, the leakage and the expense, are insidiously hidden. But, let's bring them out in the open (see the two measures above). Primary damage through leakage shows up as erosion, wear and high maintenance cost of the valve itself. In contrast, Shear-Seal valves actually improve their sealing qualities with each operation. (Write for "Super Seal explains the Shear-Seal Principle.")

Higher, yet hidden damage results when leaky valves constantly exhaust accumulators, overwork pumps and compressors, or increase the scrap rate through loss of working pressure.

Furthermore, leakage creates heat in your hydraulic system accelerating wear and deterioration in costly machinery and components. Ironically, the valves are often overlooked as the real culprit in such failures.

For greater operating economy and lower overall maintenance install leakproof Shear Seal valves.

Send FREE bulletin "Super Seal Explains the 'Shear-Seal' Principle."

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COMPANY _____

ADDRESS _____

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BARKSDALE VALVES

5125 ALCOA AVENUE, LOS ANGELES 58, CALIFORNIA

Highlights

PHENOLIC ADHESIVES FOR HIGH TEMPERATURE . . . .

. . . . and high humidity environments have been developed by North American Aviation, Inc., Los Angeles 45, California. One type, the "NAA Hi-Temp" is used for bonding metals and reinforced plastics, while a modification, "CHT" is used in the fabrication of heat resistant "sandwich constructions." Reason for the stringent requirements of adhesives is the increasing use of sandwich structures in aircraft construction to reduce weight, plus the supersonic plane which develops high skin temperatures in flight. An aluminum honeycomb sandwich structure, bonded with "CHT" withstood a load of 690 lb. at 500 F.

TO AUTOMATICALLY PRODUCE ELECTRONIC EQUIPMENT . . . .

. . . . the mechanical division of General Mills, Inc. has produced its Autofab, a machine which will assemble in little more than a minute the same number of multiple-part electronic units that it now takes one worker a full day to assemble. It requires only two workmen and a supervisor, and has a capacity of more than 200,000 assemblies a month. The machine incorporates the same basic principles and techniques for an automatic machine which will turn out completely assembled chassis for radios, television sets, and other electronic systems.

A LIQUID ACTING LIKE A SOLID SEMICONDUCTOR . . . .

. . . . has been found in molten metallic sulfides by researchers at the Metals Research Lab. of Carnegie Institute of Technology. With ordinary salts like sodium chloride, either molten or in a water solution, electrical current is carried by ions. But the molten liquid sulphides, instead of conducting electricity ionically, conducted electricity by the flow of electrons as in an ordinary wire. Unlike ordinary metals, the conductance increased with temperature.

POLYETHYLENE RESIN WITH GREATER RIGIDITY . . . .

. . . . and higher temperature resistance is now in pilot plant production at Bakelite Co., Div. of Union Carbide & Carbon Corp. The new resin is produced under conditions close to atmospheric pressure and temperature, as opposed to the old type normally produced at very high temperatures and pressures. Softening points up to about 240 F are expected for the new resin; the old type is 20 to 30 deg. less. The greater rigidity will be advantageous in the toy and large molded or vacuum formed products fields.

STUDIES OF TITANIUM ALLOYS . . . .

. . . . were necessary as a result of the brittle behavior of some titanium alloy parts used in experimental jet engines. These investigations show that the residual tensile ductility of alpha titanium (A-55, A-70, and A-110 AT) after creep testing is not affected by a combination of time up to 1,600 hours, temperatures to 1,000 F and stresses high enough to cause creep of 1-10 per cent. The alpha-beta titanium alloys such as C-110M and C-130AM had residual ductility which indicated that these alloys were not greatly affected by: For C-110M times up to 1,350 hrs., temperature to 600 F, and creep stresses sufficient to cause 1-9 per cent elongation; and for C-130AM, times up to 1,160 hrs., temperature to 600F, hydrogen content to 160 ppm at 400F, and creep stresses sufficient to cause 2-14 per cent elongation.

(*continued on page 9*)

Maximum Rust Protection

and a fine black finish for iron and steel

This long-wearing, rust resistant product is used on many types of iron and steel articles: Nuts and bolts, brackets, screws, nails, springs; tools, casters, padlocks, machine housings and castings; outdoor furniture, hinges, latches, ornamental iron.

Parco Compound is a versatile metal treatment. It is simple to operate, easy to control, dependable and uniform in results, and economical. It creates a dense coating of nonmetallic phosphate crystals over the whole surface of the article treated. There are no limitations on size or shape—any article which can be immersed in the tank can have this protection. Oil, wax, stain, or paint finishes may be used over Parco Compound, to produce maximum rust resistance with deep, velvet black appearance.

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PARCO COMPOUND — rust resistant

PARCO LUBRITE — wear resistant for friction surfaces

BONDERITE — corrosion resistant paint base

BONDERITE and BONDERLUBE — aids in cold forming of metals

TROPICAL — heavy duty maintenance paints since 1883

Highlights

TITANIUM ALLOY EXTRUSIONS . . . .

. . . . are now available from Harvey Aluminum, Torrance, Calif., in such standard aircraft structural shapes as angles, T-sections, and H-sections from alloys such as Rem-Cru RC-130B, Malloy-Sharon 3A1-5Cr, and the 3 Mn complex alloy developed by Battelle Memorial Institute. The parts have the same tolerances as specified by the Air Force for AN aluminum extrusions. The mechanical properties are the same as those specified for comparable aluminum alloy extrusions, and are uniform from surface to center and from end to end.

STANDARDIZATION OF CENTRIFUGAL PUMPS . . . .

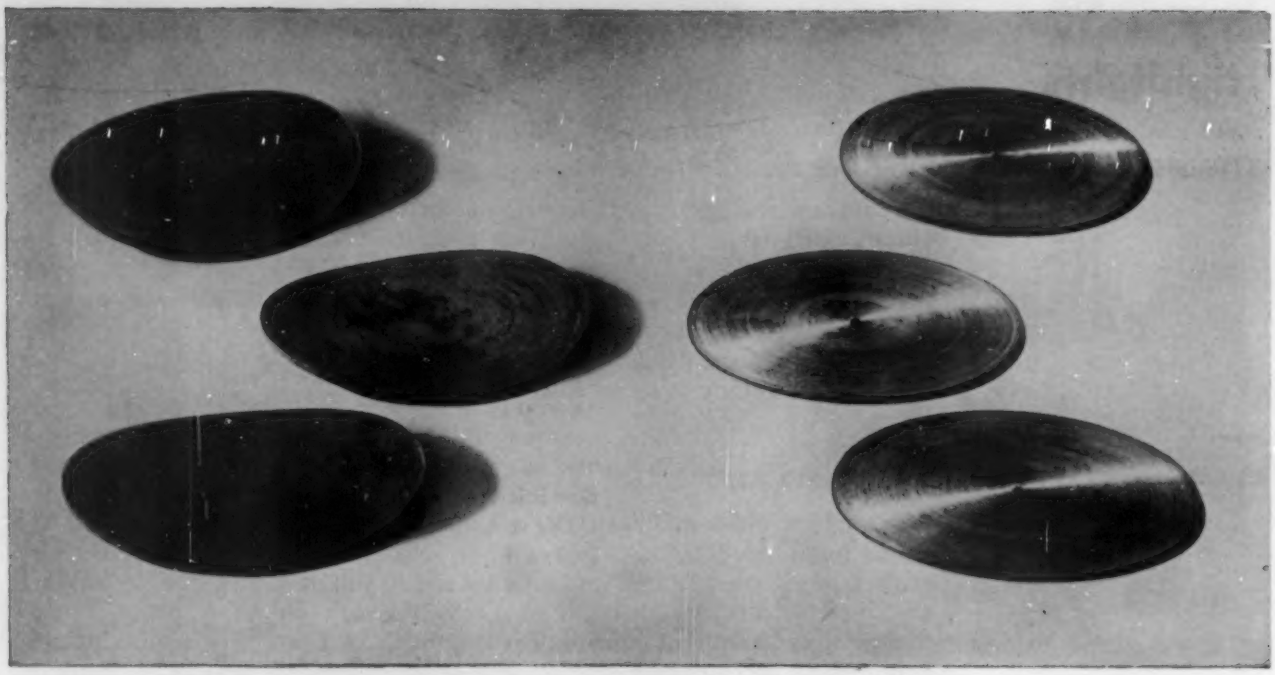
. . . . a project which is estimated to save $6.8-million a year, has been proposed by the chemical industry, and circulated by the American Standards Association. A conference to be held the early part of this month will decide whether the project should be initiated, and then to form a committee to work out the details. Made to more than 30 national organizations representing the designers, manufacturers, and users of this equipment, the proposal deals with the low pressure centrifugal pumps used by the chemical industry—those classified as horizontal, end suction, single stage and electrically driven. Approximate maximum capacity range is from 5 to 1,000 gpm, and temperatures to 500 Fahrenheit.

REDUCING THE COST OF SILICONE RUBBER PARTS. . . .

. . . . is possible, says Linde Air Products Co., a Div. of Union Carbide & Carbon Corp., as a result of their new type silicone rubber. The silicone is available in production quantities as a gum stock called W-96 silicone gum. The unique properties, according to Linde, come from the controlled number of reactive groups which have been built into each silicone molecule, and which determine the final structure of the cured rubber. The "controlled Reactivity" of the gum stock itself, also makes unnecessary many special techniques in compounding and curing, resulting in a reduction in the cost of the rubber parts, and the opening of new fields for silicone rubber. Very low compression set and good resistance to high-pressure steam are some of its good properties.

SHORTS . . . .

. . . . The first transistorized power line carrier to be placed in commercial production has been announced by Motorola, Chicago, Ill. . . . The AEC will foot most of the $25,000 cost of a study of high temperature piping to get information on thermal fatigue in metals; the ASME will put up $10,000 of the cost, and information will be available to all. . . . A magnetic device developed by Brach Mfg. Corp., Newark, N. J., is said to eliminate indoor "rabbit-ear" TV antennas, and replace most outdoor units; receives signals through magnetic absorption and has no protruding rods. . . . In March the office of Defense Mobilization ordered the diversion of 8,000 tons of refined copper to industry users "on the basis of hardship" to help ease the supply situation; even so, brass and wire mills will be short 30,000 tons for the next two months. . . . The General Electric Co. has announced a general price reduction ranging from 22 to 45 per cent on its complete line of transistors; prices will be from below $2 to about $4 each in quantity lots. . . . Lightweight titanium bolts claimed to equal the performance of high-strength steel aircraft bolts are available from Standard Pressed Steel Co., Jenkintown, Pa. . . . Primary aluminum imports from Canada will be close to 225,000 tons in 1955, compared to 195,000 tons last year; meanwhile, talks of a shortage in the U. S. continue.



Why Armco **17-4 PH** Stainless Steel **cures distortion problems**

Here's how Armco 17-4 PH Stainless Steel and standard hardenable stainless steel reacted to heat treatment. The three samples at left are all Type 431 stainless steel; the ones at the right are Armco 17-4 PH. Both sets of discs are of the same dimensions, cut from 1¼" diameter bar stock. All have been heat treated to Rockwell C-40 to C-41.

LOW TEMPERATURE DOES IT

The Armco 17-4 PH samples have only a brown heat-tint discoloration—are perfectly flat, typical of what you may expect in your own plant. The reason is that Armco 17-4 PH is a precipitation-hardening stainless steel. The parts were fully hardened by merely holding at 900 F for 1 hour and air-cooling.

On the other hand, the Type 431 samples had to be heated to 1900 F, quenched, then stress-relieved at 600 F. They are scaled and distorted.

2 PRECIPITATION-HARDENING TYPES

If you are confronted with distortion and scaling in hardening stainless steels, Armco 17-4 PH may solve your problem. It is made in billets, bars and wire only.

For unusually high mechanical properties in sheets, strip, plates, and wire, there is a companion grade, Armco 17-7 PH. This grade takes either single or double precipitation-hardening treatment, depending on form and condition.

SEND FOR INFORMATION

For complete information on the Armco Precipitation-Hardening Stainless Steels, just fill out the coupon and mail it to us.

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1095 Curtis Street, Middletown, Ohio
Send me information on your precipitation-hardening stainless steels, Armco 17-4 PH and Armco 17-7 PH.

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SPECIAL STEELS

SHEFFIELD STEEL DIVISION • ARMCO DRAINAGE & METAL PRODUCTS, INC. • ARMCO INTERNATIONAL CORPORATION

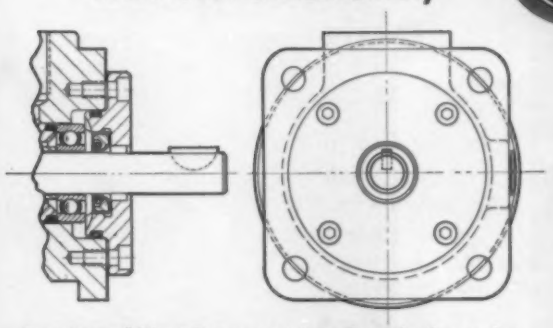
One Waldes Truarc Ring Saves a Pound in Weight Replaces Cast Retainer Plate and Four Screws

Denison Vane Type Pump/Motor

The Denison Engineering Company of Columbus, Ohio uses a Waldes Truarc Beveled Retaining Ring (Series 5002) in their pump/motor to achieve a simpler, lighter, more easily assembled unit and to cut both material costs and production time.

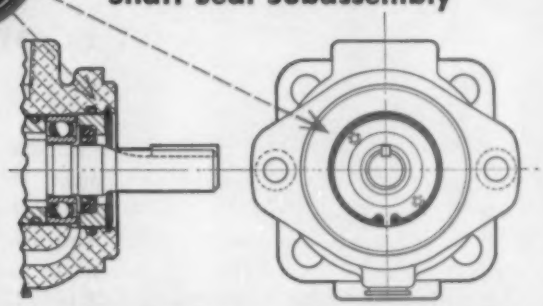
This vane-type power package operates as either a fluid pump or motor without alterations of any kind. Built for 2000 psi continuous duty, rugged construction was essential.

Shaft Seal Subassembly



Experimental Way: One cast retainer plate plus four socket head cap screws hold unit together. Assembly requires skilled labor, machinery, time-consuming careful adjustment.

Shaft Seal Subassembly



Truarc Way: Waldes Truarc beveled retaining ring (internal 5002) retains shaft and bearings, takes up accumulated tolerances rigidly, prevents leakage around shaft. Unit is one pound lighter. Assembly is quick and easy, more economical.

Wherever you now use machined shoulders, bolts, snap rings, or cotter pins, there's a Waldes Truarc Retaining Ring designed to do a better, more economical job. Truarc Rings are precision engineered, quick and easy to assemble and disassemble.

More than 5,000 stock-sizes of the different Truarc ring types available. Ninety stocking points throughout U. S. A. and Canada.

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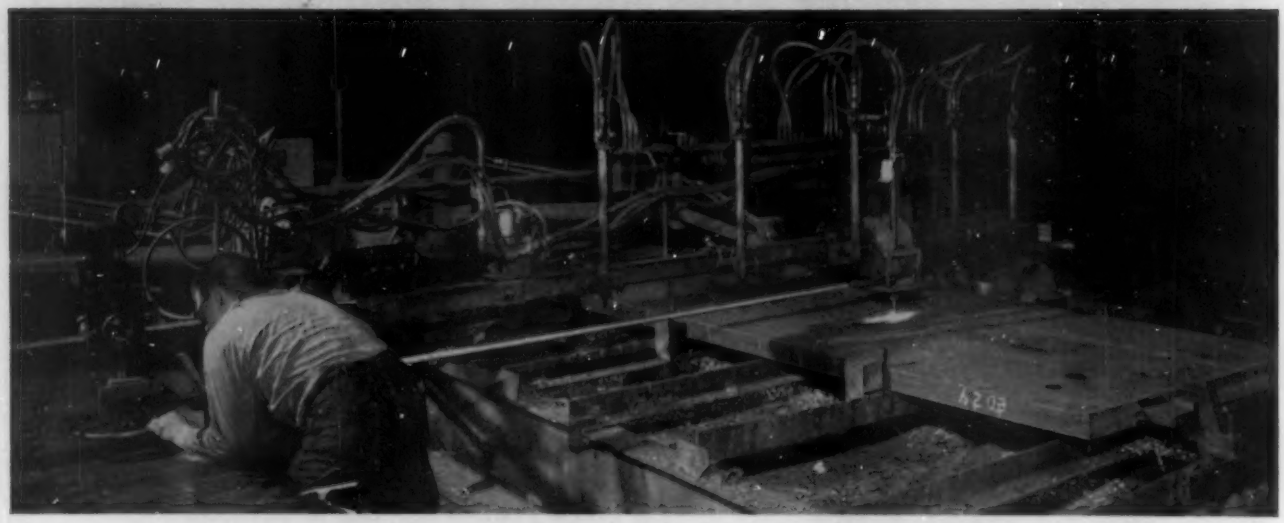
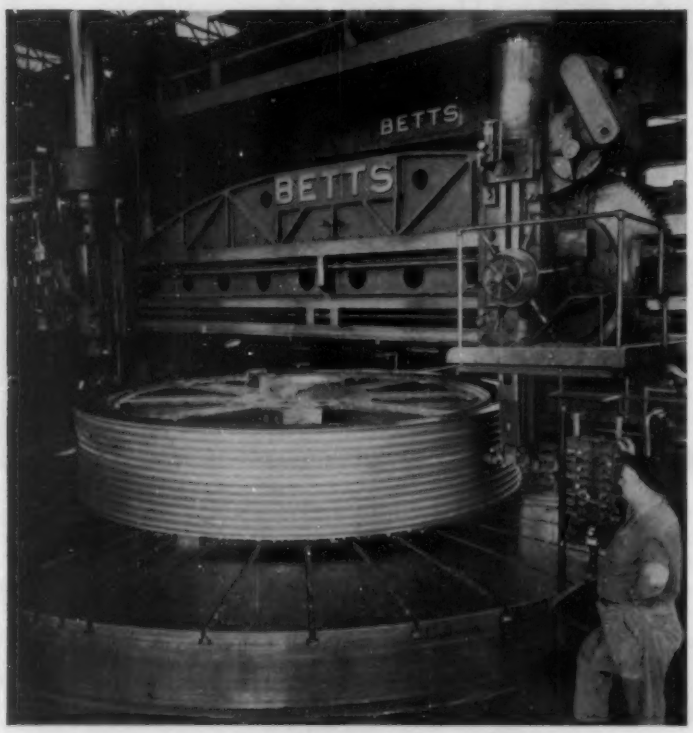
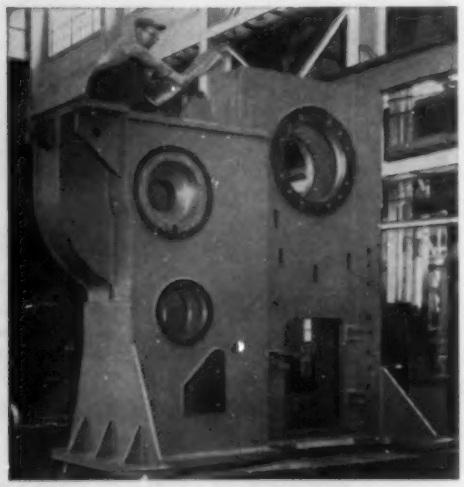
What's New in Weldments



PLAIN AND FANCY FLAME-CUTTING • There's a lot more to weldments than welding alone. At the Bethlehem Weldment Shop, where complex jobs are commonplace, this elaborate flame-cutting equipment rarely gets a breather. Set for either magnetic or electronic tracing, it can cut plain or fancy shapes in thick steel plate—and fast! Big jobs are no problem. The bed of the cutter measures 12 by 60 ft.



HIGH-CAPACITY MACHINING • If your weldment calls for machining, as did this big sheave, it's easily handled by Bethlehem. Our shops are equipped with some of the highest-capacity machines to be found anywhere. This 25-ft vertical boring mill is a good example.



COMPOSITE WELDMENT • You sometimes find that composite construction fills the bill. For instance, this 17-ton main frame for a powerful billet shear was fabricated from rolled plate, forgings and castings, all manufactured and machined by Bethlehem.

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BETHLEHEM STEEL

Leading design engineers choose this

Chain for severe conditions

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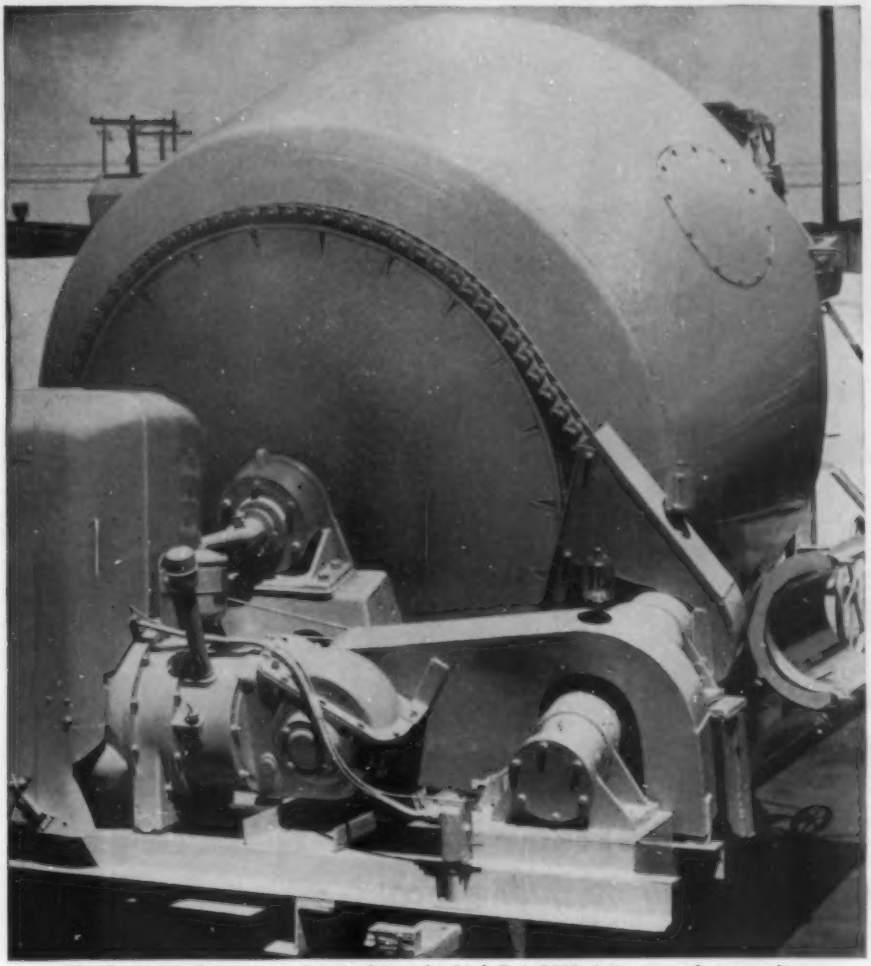
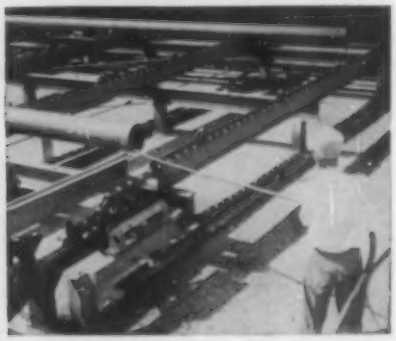
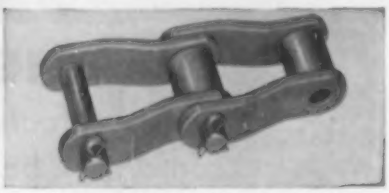


Truck-mounted concrete mixer is driven by Link-Belt LXS chain (guard removed).



Pipe mill cooling beds use LXS chain with attachments to move heavy pipe smoothly.

Advance-design shovel-crane gets its traveling and steering power through LXS chain.



Accurate sizing of full-round pins, bushings and pitch holes of LXS chain assures proper joint clearances and press fits.

No ONE chain serves every purpose--
get the RIGHT one from Link-Belt's *complete* line

FOR long life under severe drive or conveyor service, Link-Belt LXS chain is the choice of more and more leading designers. Here's a fabricated steel roller chain that *combines ruggedness with accuracy,* thanks to the manufacturing refinements that are a by-word at Link-Belt.

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TORRINGTON Spherical Roller Bearings

are manufactured with accurate geometrical conformity between races and rollers for ultimate capacity and performance.

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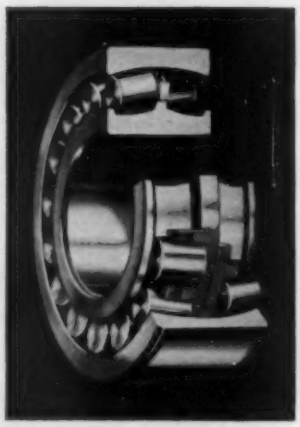

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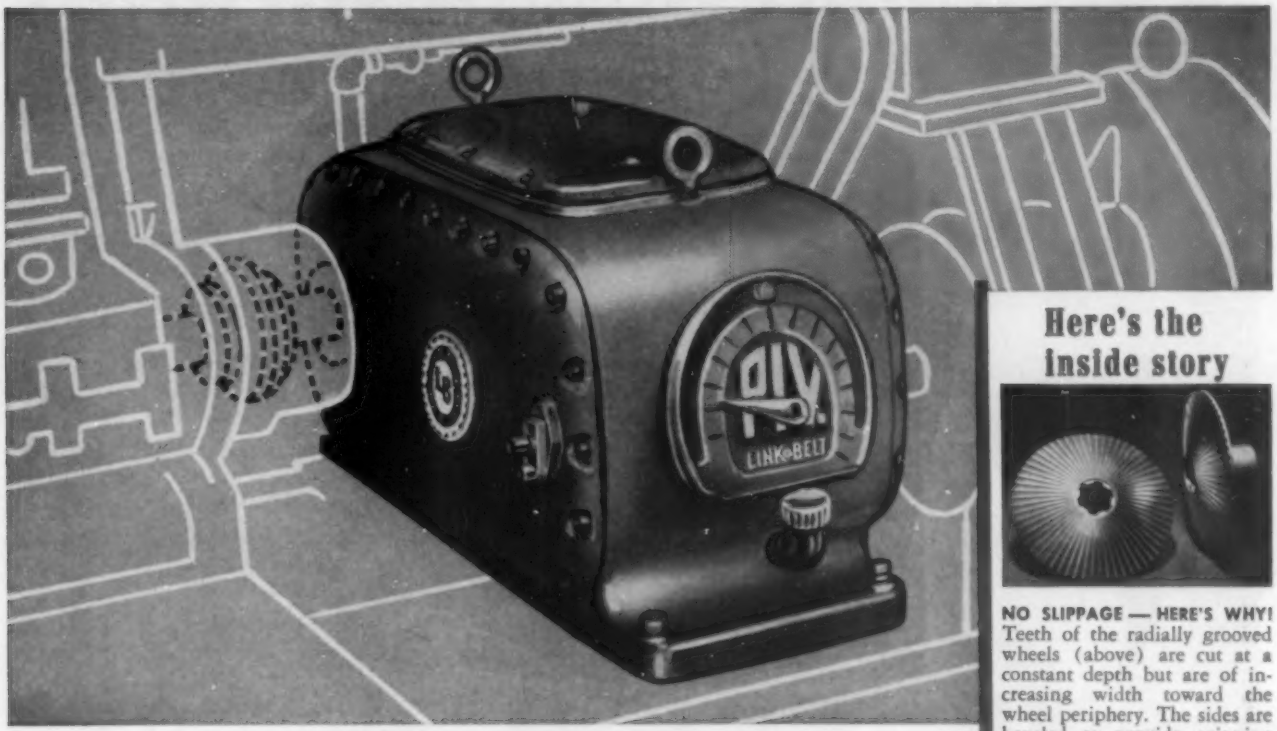
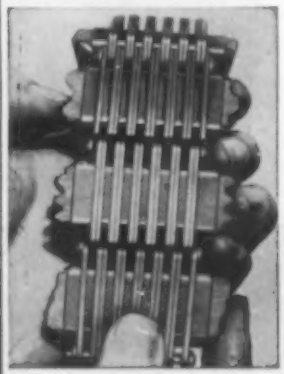
For positive, stepless speed selection all industry uses Link-Belt P.I.V.



Here's the inside story

NO SLIPPAGE — HERE'S WHY! Teeth of the radially grooved wheels (above) are cut at a constant depth but are of increasing width toward the wheel periphery. The sides are beveled to provide gripping areas for the self-tooth-forming chain (below). The chain slats shuffle back and forth between the wheels—mesh fully when they engage.



Operates independent of friction from maximum to minimum speeds

FOR speed changing that's completely positive . . . completely stepless—Link-Belt's P.I.V. has no equal. Here's a totally enclosed all-metal variable speed drive that provides exact speed selections—independent of friction.

Following are just a few of the jobs P.I.V. performs with matchless precision:

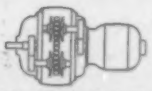
- Exact synchronization of rotating parts and machines
- Accurate control of process speeds
- Precise regulation of rotary motion
- Flexible, accurate timing
- Stepless control of production lines or individual machines

Find out how P.I.V. can extend the useful range of your machine operations. Your Link-Belt office or distributor will give you all the facts. Call today, or write for Book 2274.

4 of 16 P.I.V. types — ½ to 25 hp — ratios to 6:1

Basic P.I.V. Like all others, it is built for horizontal or vertical mounting.

P.I.V. with single reduction input or output helical gears.



Motorized P.I.V. with single reduction input and output helical gears.

Motorized P.I.V. with single reduction input and double reduction output helical gears.

LINK-BELT P.I.V. VARIABLE SPEED DRIVE

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Can you use a compact drive with infinitely variable speeds?

HERE IT IS

Cleveland Speed Variator

NOW available in 9 sizes, ranging from one-half to 10 horsepower at 1750 input RPM.

INFINITELY variable, stepless speeds within a 9:1 range (from ⅓ to 3 times the input speed).

Smooth, instant change of speed by simple manual adjustment or by remote control devices, either manual or power operated.

Operating efficiencies—75% to 90%.

Coaxial input and output shafts, rotating in same direction, either clock-wise or counter clock-wise.

Ample bearing support for both input and output shafts to carry overhung pulleys.

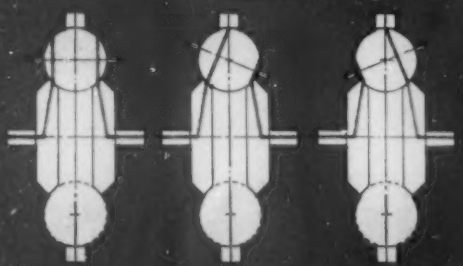
Compact and inherently quiet and smooth running, due to simple construction.

Minimum maintenance and long life, due to absence of belts and other complicated linkage.

Performance proved by prolonged tests in the laboratory and field operation.

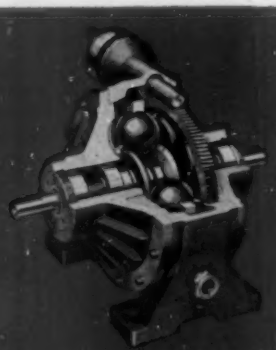
These are the outstanding advantages of the Cleveland Speed Variator. It is now ready for service. Immediately applicable to a wide variety of machines and equipment where a dependable variable speed drive is required. For detailed description and specifications, write for Bulletin K-100.

HOW THE CLEVELAND SPEED VARIATOR WORKS



Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts.

Relative speeds of the shafts are adjusted by changing the positioning of axles on which the balls rotate (see diagrams, left, and cutaway view, right).



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Speed Variator Division, 3279 East 80th St., Cleveland 4, Ohio

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"The lady who is wise will ask to be advised if it's powered with a Delco Electric Motor."

Delco Electric Motors give you peak performance with complete dependability because each one is "job-fitted" to your most exacting requirements. Job-fitted means Delco *engineers* work with *your engineers* to make certain the application is absolutely right. This famous Delco Products service is your assurance that

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will do a Better Job when

"Job Fitted" Power Them

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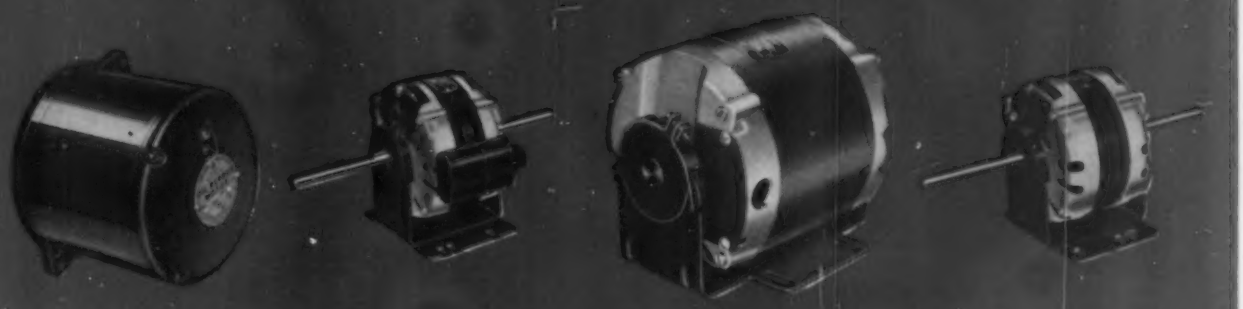

your products will consistently operate with maximum efficiency. It means the Delco Electric Motors that power your products will deliver topnotch service over longer periods of time . . . at less cost for maintenance.

You can be just as sure of another kind of dependability, too, whenever you work with Delco . . . *dependability of delivery.* Volume producers know Delco will deliver on time. Whatever the size of your order, wherever and whenever you want them, your motors will be there on schedule. And wherever your products go, throughout the world, Delco parts and Delco service facilities are always nearby.

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DELCO *Electric* MOTORS

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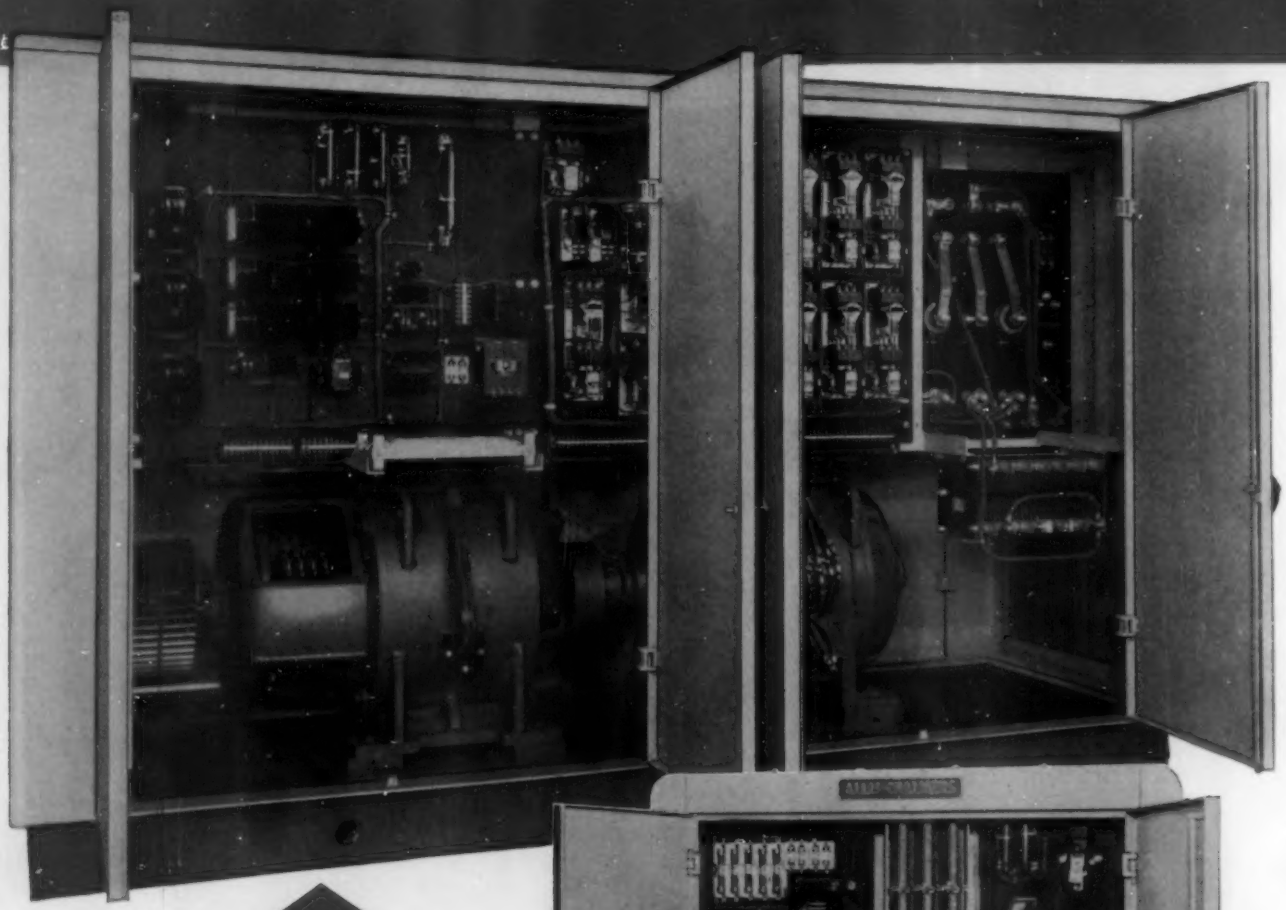
Proved best by Performance!

Get the Drive

Tailored to Your Speed



A-C package drive, Size 5, 125 hp. Reversing, dynamic braking (rear view).

Size 2 packaged drive, 25 hp, with electronic speed regulation ¼ of 1% based on top speed, 3550/50 rpm.

A-C ALLIS-CHALMERS

ALLIS-

Control Needs

ALLIS-CHALMERS Package Drive Gives You

- ★ Wide speed range
- ★ Precise speed control
- ★ Operation from one or more points
- ★ Simple installation
- ★ Reduced maintenance

If you need speed control for up to 200 total horsepower plus special performance characteristics such as threading, jogging, dynamic braking, etc., the Allis-Chalmers package drive will provide these functions in one easy-to-specify unit. The package drive itself consists of a motor-generator set and control components mounted in a well-ventilated cabinet. Control stations and dc drive motors may be placed wherever convenient. Installation is simple because the unit is factory-wired and ready to operate. Maintenance is reduced because cabinet keeps equipment clean and out of harm's way. All three of the basic components — m-g set, control and drive motors — are designed to operate as a unit.

Engineering Assistance

Allis-Chalmers application engineers are thoroughly familiar with OEM problems and will be glad to help you at every stage of your operation. For help, call your nearby Allis-Chalmers District Office. For literature, write Allis-Chalmers, Milwaukee 1, Wisconsin. Ask for Bulletin 51B8166. A-4620

Vari-Pitch is an Allis-Chalmers trademark

Other Allis-Chalmers Speed Control Drives

Mechanical

Where a moderate speed range is required and where the machine may be stopped to make required speed changes. Horsepower range — 1½ to 300. Speed adjustment range — 9 to 28 percent. Two *Vari-Pitch* sheaves used together double range of adjustment.

Mechanical

Where speed must be changed while machine is in motion. Particularly good for machines requiring fine adjustment while operating. Double range of adjustment may be obtained by using two *Vari-Pitch* sheaves. Horsepower range—1½ to 600. Speed adjustment range —9 to 28 percent with one *Vari-Pitch* sheave.

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Where stepped speed control is satisfactory. Available with stepless control in larger sizes by using liquid rheostat. Speed is varied by means of control on secondary windings of motor. Horsepower range — 5 hp and up. Speed adjustment range — 30 to 96 percent of synchronous speed for fan duty.

CHALMERS

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How to Control Temperature With Liquid Filled Bellows Systems

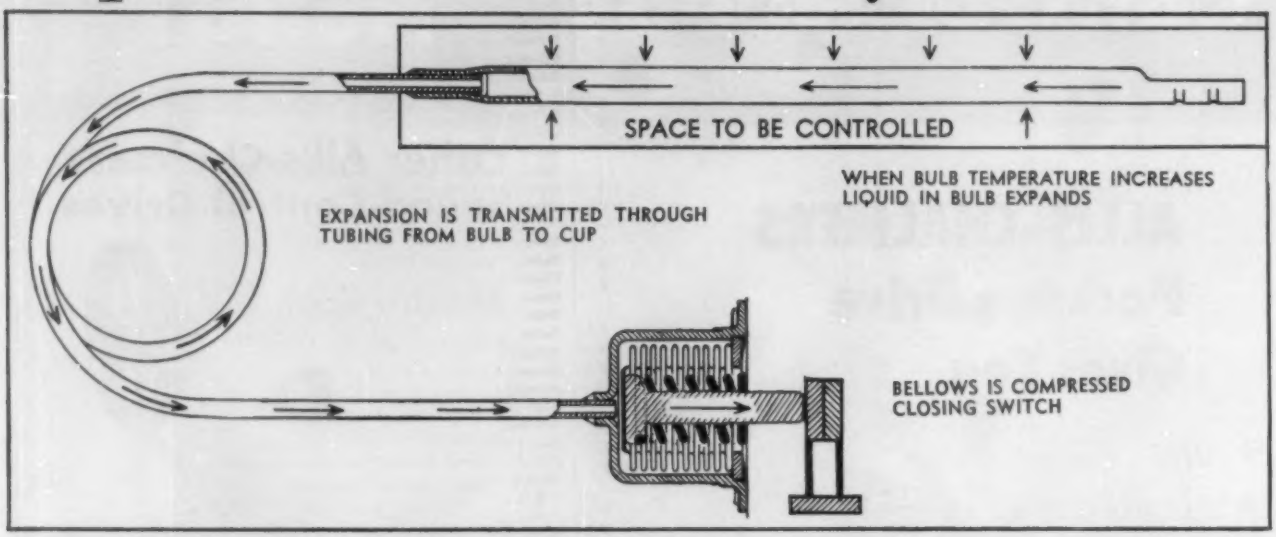


Fig. 1. Liquid filled bellows systems provide remote control of a wide temperature range with a single adjusting device. Bellows actuating movement is closely proportional to the temperature range throughout the entire operating range of the system. The differential required to operate these devices is directly related to the range of temperature to be controlled. A device that provides control over a wide temperature range normally requires a relatively wide differential to operate it at any given setting. However, proper design of switches or valves can make these systems quite sensitive.

ADVANTAGES OF LIQUID FILLED BELLOWS CONTROLS

For the remote control of temperature, liquid filled bellows assemblies provide simple, efficient, direct-acting systems. Utilizing the thermal expansion of a liquid selected for the particular application, the bellows responds with sufficient force and degree of motion to actuate switches and valves without the need for elaborate amplifying systems.

They can be used for temperatures as low as —100 F. and as high as 700 F. In addition, these units provide "one knob control" of temperature over a *wide range*. A common example is the ordinary domestic oven in which a selected temperature can be maintained anywhere in the range from 150 F. to the top limit of the oven — usually about 600 F.

Since these systems operate on the thermal expansion of a liquid, they are insensitive to ambient pressure changes.

Liquid filled bellows systems are highly versatile and offer many possibilities to designers seeking low cost, accurate, dependable temperature controls for consumer, industrial or commercial product applications.

Long experience record. Being one of the most widely used thermostatic controls, a great deal is known of the inherent characteristics of liquid filled thermostatic assemblies. Performance can be accurately predicted for applications when operating conditions are known. Furthermore, the design considerations are so well known that it is usually not difficult to design a liquid type thermostatic assembly to fit the requirements of any application for which this type of control is suited.

Operating principle. (fig. 1). In its simplest form, the liquid filled thermostatic assembly consists of a bulb, capillary and bellows. The bulb is the temperature-sensing element and is located in the chamber whose temperature is to be controlled. The bellows is the responsive element and can be located together with the switch or valve it will actuate at any remote location within a reasonable distance of the bulb. A capillary, a special small bore tubing, connects bulb and bellows. The entire assembly — bulb, capillary and cup — is completely filled with a liquid chosen for the particular range of temperature to be controlled.

As the temperature in the chamber rises, the liquid in the bulb expands through the capillary into the cup, compressing the bellows and moving the attached rod to actuate a switch or valve.

DESIGN CONSIDERATIONS

Bellows stroke. The amount of bellows movement necessary to actuate the switch or valve varies with the nature of the application. Design of bulb volume and bellows effective area control the movement to meet these requirements. A large volume bulb and small bellows results in a longer stroke and vice versa. Bellows of 15/32" or 9/16" diameter are common sizes.

The total stroke or travel to be ex-

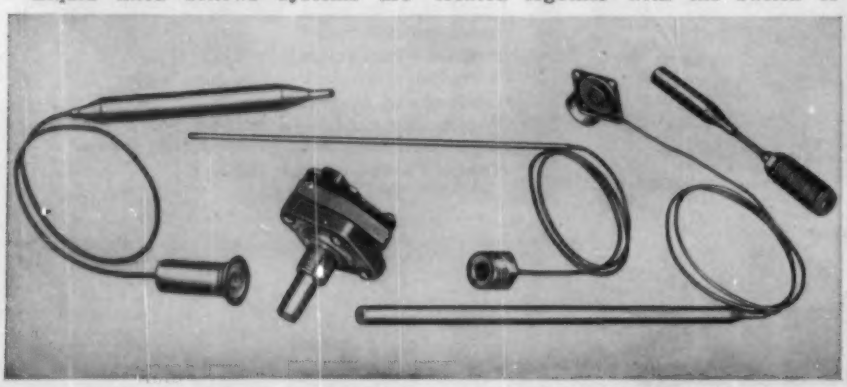


Fig. 2—Representtive open type and cup type liquid-filled bellows thermostatic assemblies. Cup type is preferable, being inherently stronger, easier to mount and with bellows protected from damage by handling.

Fig. 3. Electric and gas ranges are commonly equipped with liquid filled bellows controls. Bellows movement operates electric switches that turn heating elements on and off. In gas ranges bellows operates modulating valve to control flow of gas.

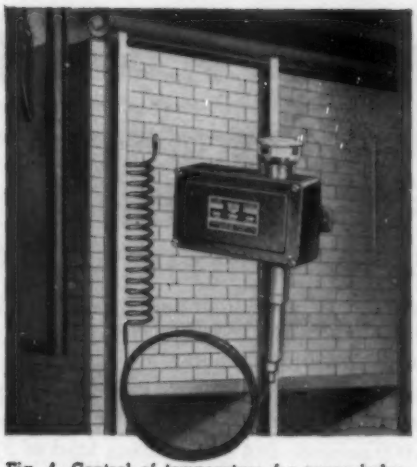


Fig. 4. Control of temperature for many industrial processes is achieved through liquid filled bellows assemblies. Typical applications: Kilns, steam tables, kettles, ovens, furnaces.

pected of a bellows in this type of application is approximately 25% of its length.* This is the total amount of bellows movement available over the entire range of temperature which the device will encounter.

For example: a bellows one inch long will provide a total travel of about one-quarter inch.* Used in a temperature range of 500 F, bellows movement would be .0005" per degree. In a 100 F range, movement per degree would be .0025".

In computing bellows movement care must be exercised to consider the highest ambient temperatures encountered during shipment, storage or extraordinary conditions of service. Heat applied to a fluid in a closed system can generate large forces and result in damage. A unit intended to control temperatures between 50 F and 70 F for example, may experience temperatures as high as 140 F. Bellows movement must therefore be figured for the range 50 to 70 F (Normal ambient) resulting from expansion of the liquid in the bulb. In addition, the entire volume of liquid in the bulb, bellows and capillary will expand between 70 and 140 F.

∴Coeff. of Expansion [Bulb Volume × (70 − 50) + (Bulb + Bellows + Capillary volumes) × (140 − 70)] gives total liquid expansion. This expansion divided by the effective area of the bellows will give the total movement over the complete range from 50 to 140 F. The total movement should not exceed the allowable travel discussed above. Temperatures *lower* than the operating range need not be considered as a factor.

Loading springs are generally used with liquid filled bellows systems. They make certain that the bellows follows the volume changes of the liquid accurately. Springs used for cup type assemblies are lighter than those required for equivalent open type assemblies (see fig. 2) because the natural spring of the bellows in a cup assembly actually helps the loading spring to perform its proper function. The open type bellows assembly opposes the loading spring and therefore, a heavier loading spring is required. Frictional forces for devices utilizing cup type assemblies are generally lower than those for equivalent open type units.

Bulb and filling medium. There are a number of liquids with properties suitable for use in thermostatic assemblies intended for service anywhere from −100F to 700 F. Some typical ones are shown in fig. 7. In addition to the consideration of adequate volume in relation to the bellows so as to provide sufficient actuating stroke, bulb design is concerned with securing the proper heat transfer so that temperature changes in the controlled chamber will be quickly reflected in bellows movement. Both filling medium and bulb design are critical elements and should be chosen only after consultation with Clifford engineers.

Responsiveness of liquid filled bellows assemblies is very good and they can be used in systems requiring rapid response. The only heat required to change the temperature of the bulb is that required by the specific heat of the bulb material and its enclosed liquid. Much depends upon the specific conditions of the application. In rapidly moving air, for example, time constants as low as 10 seconds are practical. When the bulb is immersed in a liquid the device may operate up to five times as fast.

The open type thermostatic assembly is used for some applications where cup type (fig. 1) may not fit. Operating principle is the same except that the bellows itself is filled with liquid and expands with rise in temperature to actuate the switch or valve rather than being compressed as in cup type.

Open assemblies require a heavier loading spring than the cup type. The bellows is more susceptible to damage due to handling and it is more difficult to mount this type of assembly. Cup assemblies are more rugged. They protect the bellows and apply the pressure to its outside surface. The bellows operates in compression — for which it is best suited, resulting in longer life.

Clifford will send you additional data. If you have an immediate problem, send a sketch showing controlling conditions. We will recommend a suitable control.

Clifford Manufacturing Company, 122 Grove Street, Waltham 54, Mass. *Division of Standard Thomson Corporation.* **Sales Offices in New York, Detroit, Chicago, Los Angeles, Waltham, Mass.**

Coefficients of Thermal Expansion

	Coefficient* (in.²/in.²/deg F) × 10⁻⁶ (0 – 1 – 2)	Freezing Point (F)	Boiling Point (F)	Max. Op. Temp. (F)
Mercury	1	− 38	675	
H. T. A.†			672	600
Glycerine			554	350
H. T. C.†		29	528	700
H. T. B.†		54	500	700
Trichlorobenzene		45	415	450
O-Toluidine		3	392	450
Ethylene Glycol		11	388	350
Aniline		− 22	364	450
O-Dichlorobenzene		2	357	450
Chloronaphthalene		− 35	321	450
Turpentine			311	350
Xylene		− 53	283	400
Monochlorobenzene		− 50	269	450
Glycerine-Water (62:38 vol.)		− 48	235	350
Toluene		−139	231	400
Water		32	212	
Trichloroethylene		− 99	186	250
Benzene		42	176	500
Ethyl Alcohol		−174	173	250
Carbon Tetrachloride		− 9	170	250
Methyl Alcohol		−143	148	300
Chloroform		− 82	142	250
Acetone		−138	133	250
F-113		− 31	118	250
Methylene Chloride		−142	104	300
Ethyl Ether		−177	94	250
F-11		−168	75	250
Ethyl Chloride		−218	55	250
F-21		−197	48	250
Methyl Bromide		−137	38	250
Butane		−211	31	400
Sulphur Dioxide		−105	14	800
Isobutane		−229	10	400
Methyl Chloride		−146	−11	400
F-12		−247	−22	250
Ammonia		−107	−28	
Propane	2.4	−310	−44	400

* Values increase with temperature; for example, coefficient for trichlorobenzene ranges from 0.00044 in the region of its 45 F freezing point to 0.00070 at its recommended maximum operating temperature, 450 F.

† Special high-temperature service compounds.

Fig. 6. Representative filling mediums for liquid type assemblies.

* *For accurate information, refer to bellows table of characteristics obtainable upon request.*

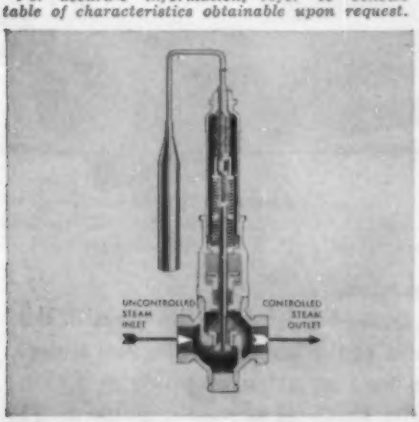


Fig. 5. Steam regulators are typical applications for liquid filled bellows assemblies. Cross section shows a Leslie Temperature Regulator used in cooling service. The rugged thermostatic element has an adjustable temperature range up to 350 F.

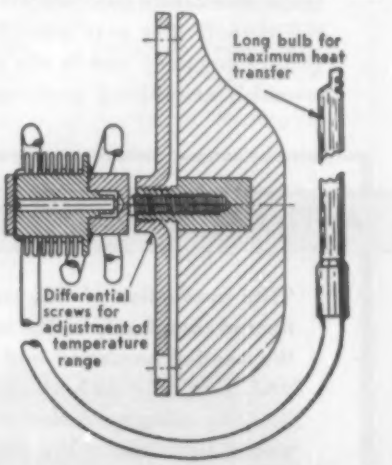
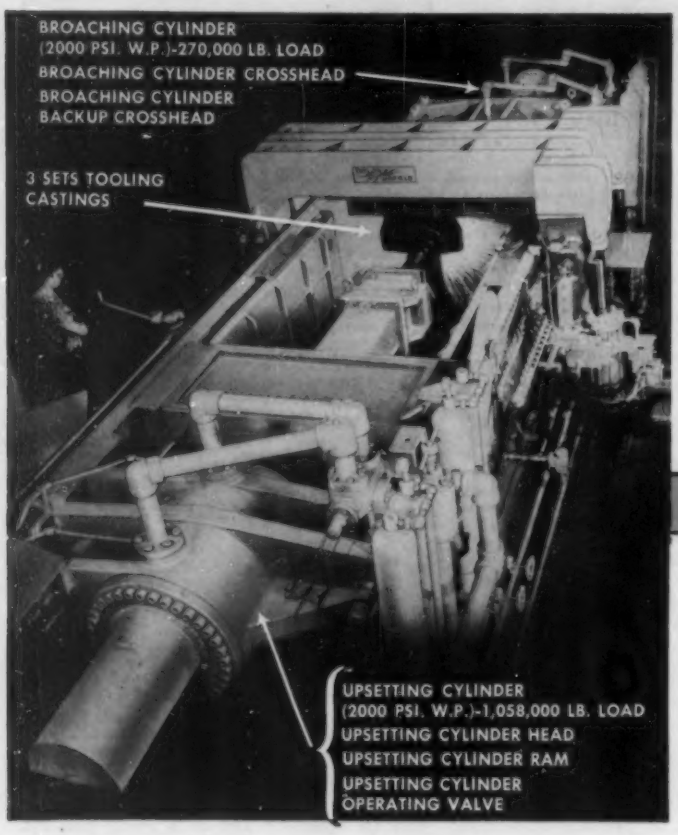


Fig. 7. Open type liquid filled control with adjusting mechanism. Similar mechanisms can be provided for cup type. 7.4.81

HYDRON
CLIFFORD
MANUFACTURING CO.
WALTHAM, MASS

The MEEHANITE® Casting Reporter



20 TONS OF MEEHANITE CASTINGS IN THIS 500-TON RESISTANCE WELDER

The Taylor-Winfield Corporation, Warren, Ohio, engineered and built a 500-ton resistance welder, (largest of its kind in the world), for the Cleveland Pneumatic Tool Company. It has an upsetting load of 1,058,000 pounds and a broaching load of 270,000 pounds.

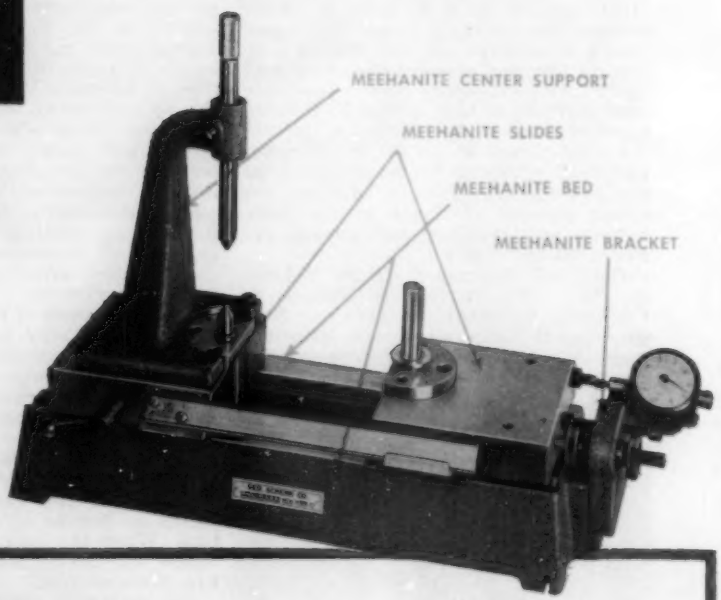
Taylor-Winfield engineers chose Meehanite castings as the heart of this huge welder because of their high strength, their pressure tightness, and their wearing properties. The illustration shows the vital Meehanite parts.

As The Manufacturer Says:

"Due to Meehanite Metal's close or fine grain, the machining qualities are excellent and give us better finish and greater strength. Meehanite's heat-treatability gives us better rams for our press welders."

PRECISION INSTRUMENT MANUFACTURER SPECIFIES MEEHANITE CASTINGS

The George Scherr Co., Inc., New York City, manufacturers of precision measuring and testing instruments, has found that insisting upon Meehanite components in the building of their spur gear tester has resulted in greater economy and in the elimination of assembly and fitting problems.



As The Manufacturer Says:

"The production of this testing machine was engineered completely by the use of Meehanite castings. We needed hardened and ground ways in the bed and, similarly, in both slides. If we had provided these by using hardened and ground steel inserts, it would have made the production of the machine much more expensive.

"Instead, we flame-harden both the ways in the bed and the ways at the bottom of the two slides. As a result, we have no extra assembly or fitting problems, and the finishing of all the guide ways is a simple surface grinding operation."

Industries report what Meehanite Castings have done for them

MEEHANITE COMPONENTS IN HYDRAULIC UNIT SEAL ASSEMBLY

The Twin Disc Clutch Company, Hydraulic Division, Rockford, Illinois, is using Meehanite components to improve performance and reduce maintenance.

The seal nose pieces (Fig. 1) for the Fluid Drive Seals are heat treated after machining. They are brought to a heat of 1580-1610 F 6 to 8 hours and packed in fine carburizing compound to prevent decarburization. They are then quenched in oil and drawn at 400-425 F for 4 hours.

It is necessary that the seal surface be ground and lapped flat within 6 wave bands of green-yellow light (.000069") and have maximum profilo-meter reading of 12 micro-inches.

Fig. 2 shows the seal test stand in operation. On the stand are two Torque Converter Seals using Meehanite castings, the oldest having been run for 7,724 hours at 50 psi and 2,500 rpm.

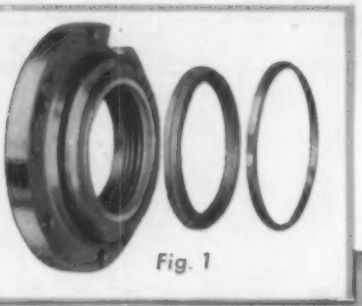


Fig. 1

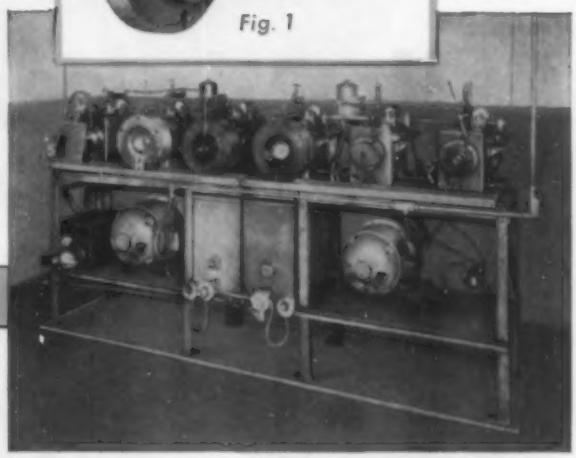


Fig. 2

As The Manufacturer Says:

"Meehanite metal, noted for its high tensile strength, provides many advantages for its use as seals for Twin Disc Hydraulic Torque Converters and Fluid Couplings.

"It has proved to have excellent wear properties and provides very uniform hardness in the heat treating process."

ONLY A **MEEHANITE** FOUNDRY CAN MAKE **MEEHANITE** CASTINGS

The American Laundry Machinery Co.	Rochester, New York
Atlas Foundry Co.	Detroit, Michigan
Banner Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington and Dover, New Jersey
Blackmer Pump Co.	Grand Rapids, Mich.
Compton Foundry	Compton, Calif.
Continental Gin Co.	Birmingham, Alabama
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio & Grove City, Pa.
Crawford & Doherty Foundry Co.	Portland, Oregon
DeLaval Steam Turbine Co.	Trenton, New Jersey
Empire Pattern & Foundry Co.	Tulsa, Oklahoma
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio
General Foundry & Manufacturing Co.	Flint, Michigan
Georgia Iron Works Co.	Augusta, Ga.
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Hardinge Company, Inc.	New York, New York
Hardinge Manufacturing Co.	York, Pennsylvania
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Koehring Co.	Milwaukee, Wisconsin
Lincoln Foundry Corp.	Los Angeles, California
Palmyra Foundry Co., Inc.	Palmyra, New Jersey
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Sonith Industries, Inc.	Indianapolis, Ind.
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
Valley Iron Works, Inc.	St. Paul, Minnesota
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Hartley Foundry Division— London Concrete Machinery Co., Ltd.	Brantford, Ontario
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Write for your copy of **"The Handbook of Meehanite Metals"**

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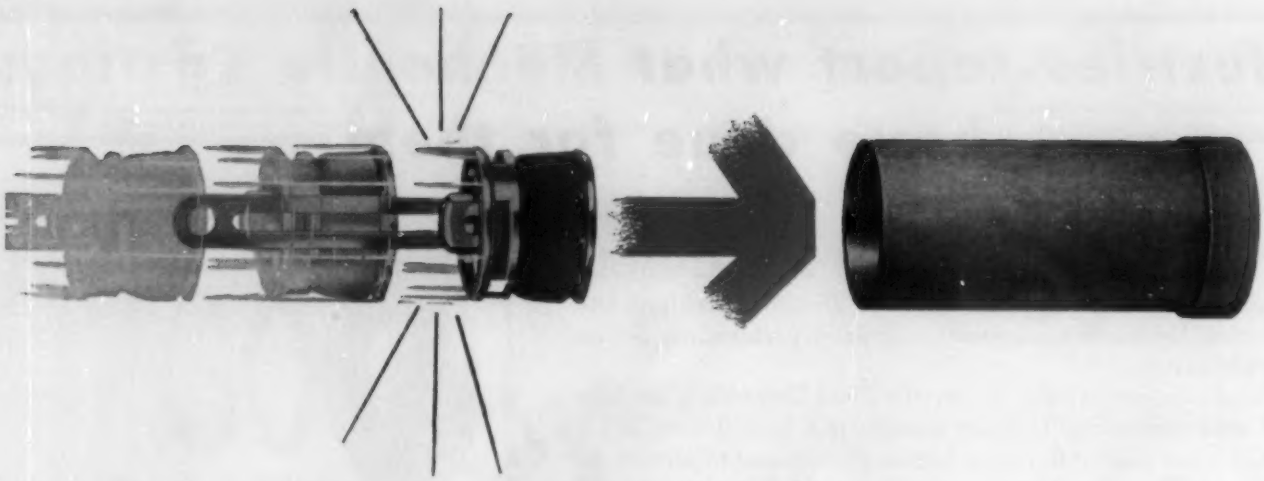
MEEHANITE METAL® CORP.

714 North Ave., New Rochelle, N. Y.



How to soak up shock and

Underwood Corporation did it by using Republic ELECTRUNITE Stainless Steel Tubing

This was the problem: find a material for the cylinder in the carriage shock absorber on an accounting machine. The cylinder must have an accurate bore, little variation in diameter, and negligible eccentricity. It must also have a suitable finish to reduce drag, because the piston which fits inside must be completely retracted in less than a tenth of a second.

Republic metallurgists suggested ELECTRUNITE Stainless Steel Tubing. It was drawn to meet dimensional requirements. The finish was excellent. And Underwood reports good service life because of excellent wearing qualities.

Republic Steel Corporation
3150 East 45th Street
Cleveland 27, Ohio

REPUBLIC STEEL

- ☐ Enduro® Stainless Steels
- ☐ ELECTRUNITE® Stainless Steel Tubing and Pipe
- ☐ Republic Nuts and Bolts
- ☐ Republic Chateaugay Pig Iron

Name_____ Title_____

Company_____

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R-7008

BUSINESS MACHINE PARTS COST LESS because they last longer when they're made of Republic Enduro Stainless Steel. On this Addressograph-Multigraph office machine, ink corroded the carbon spring steel from which the ribbon guards and lister spacing bands were made originally. Carbon steel also cracked under the operating strain. Enduro Stainless Steel resists this corrosion, has the necessary springiness and wears well, despite the abrasive action of moving the ribbon.

cut costs!

Underwood now saves 75 cents on material costs for each shock absorber.

This is only one of many customers for whom Republic has saved money. Sometimes we save material costs. Sometimes production costs. Often, both. And since we manufacture both stainless steel and carbon steel tubing in many analyses, we are equipped to help solve all kinds of tubing problems.

Fill out the coupon below for more facts on Republic ELECTRUNITE Mechanical Tubing. Or call your nearest Republic district sales office.

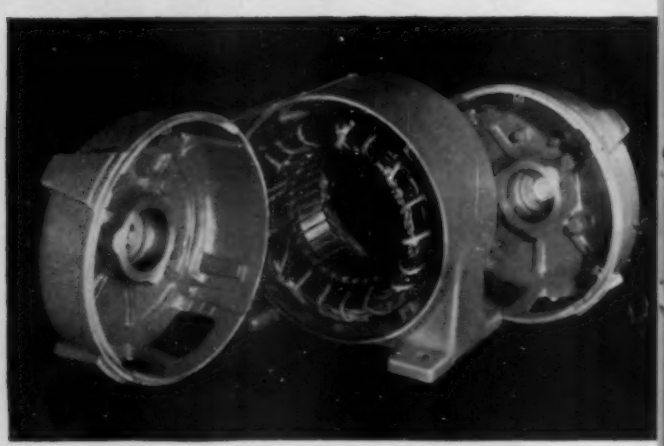
ECONOMICAL MACHINING IS ONLY ONE REASON why a leading maker of heat-resistant glass products uses Republic Chateaugay Pig Iron for glass molds. This premium pig iron, supplied exclusively by Republic, also assures a dense, fine grain structure; longer mold life; fast-flowing and even-cooling characteristics. Hard surfaces resist heat and wear.

CUTTING COSTS ALSO APPLIES TO BUYING FASTENERS for your assembly and maintenance work. One call to your Republic Distributor gets all the fasteners you need. There's no shopping around, no time lost. Paper work is reduced. And, you get exactly what you want because Republic makes and stocks over 20,000 types and sizes of regular fasteners, everything from machine bolts to sheet metal screws. You can depend on Republic Fasteners for quality, uniformity, ease of application, long service life. Quick delivery, too.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

MOTOR FACTS ON INDUSTRY'S
MOST-PREFERRED "POWER PACKAGE."



Electrical System Fact: New fortified insulation includes exclusive Bondar, Bondite and Mylar* for greater protection against the toughest operating conditions.

*Du Pont registered trade-mark

FACT:

The new Life-Line A has stronger insulation than any other motor on the market

Meaning what? Simply that the new Westinghouse Life-Line® "A" motor with new fortified insulation can withstand heavier overloads and operate at higher temperatures than any other motor you can buy.

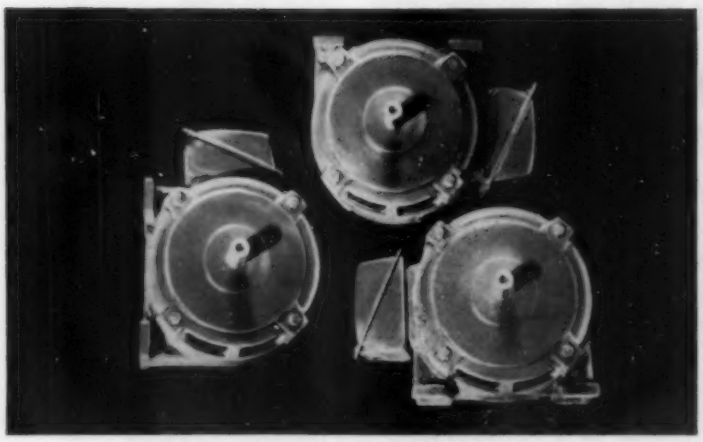
Similar design advances in the mechanical and lubrication systems make Life-Line "A" industry's most preferred motor.

It takes the right combination of *all three systems*—electrical, mechanical and lubrication—to build the best package of power on the market.

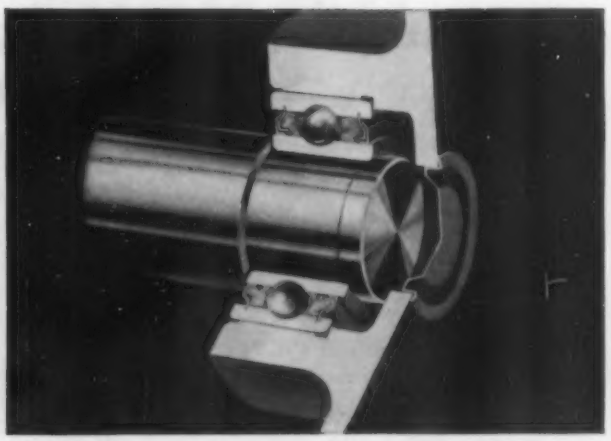
Get all the facts by calling your Westinghouse sales engineer . . . *The Man With The Facts!*

J-21877

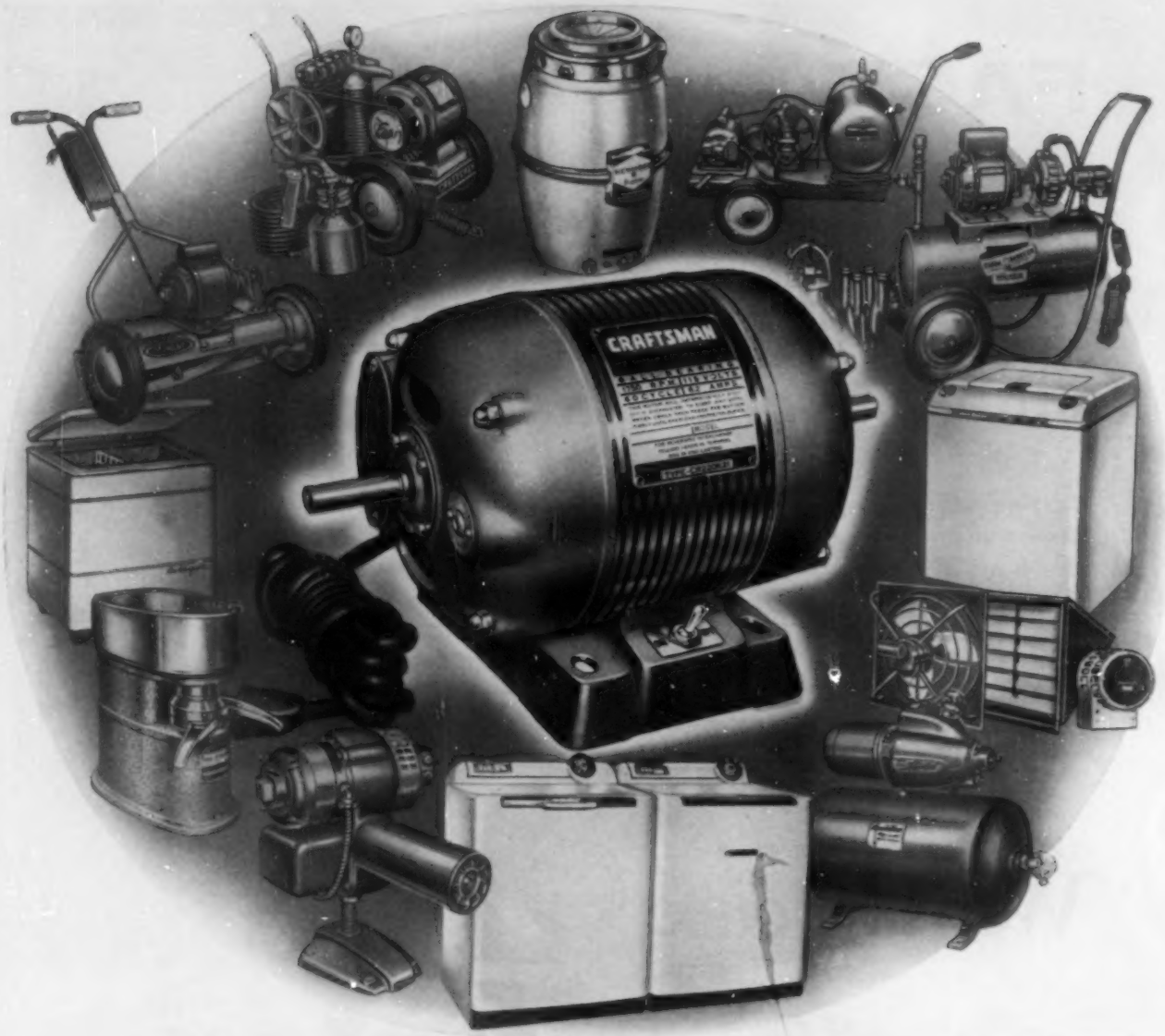
YOU CAN BE SURE...IF IT'S Westinghouse



Mechanical System Fact: New cast-iron housing on both drip-proof and totally-enclosed types. Ventilation openings only in end brackets make the motor drip-proof whether mounted on floor, ceiling or wall.



Lubrication System Fact: New "4-way sealed", pre-lubricated bearing eliminates completely the 3 main causes of bearing failure: 1) contamination, 2) over greasing, 3) wrong grease.



SEARS, ROEBUCK and CO. PROTECTS *"Buy with Confidence"* Quality

with KLIXON PROTECTED MOTORS

Sears, Roebuck and Co. is the world's foremost mail order organization and leading operator of wholly owned retail stores.

Among their well-known merchandise are many products which are operated by electric motors. To safeguard them against burnouts and thus insure dependable operation of the equipment for their customers, Sears specifies that these motors be equipped with KLIXON Protectors.

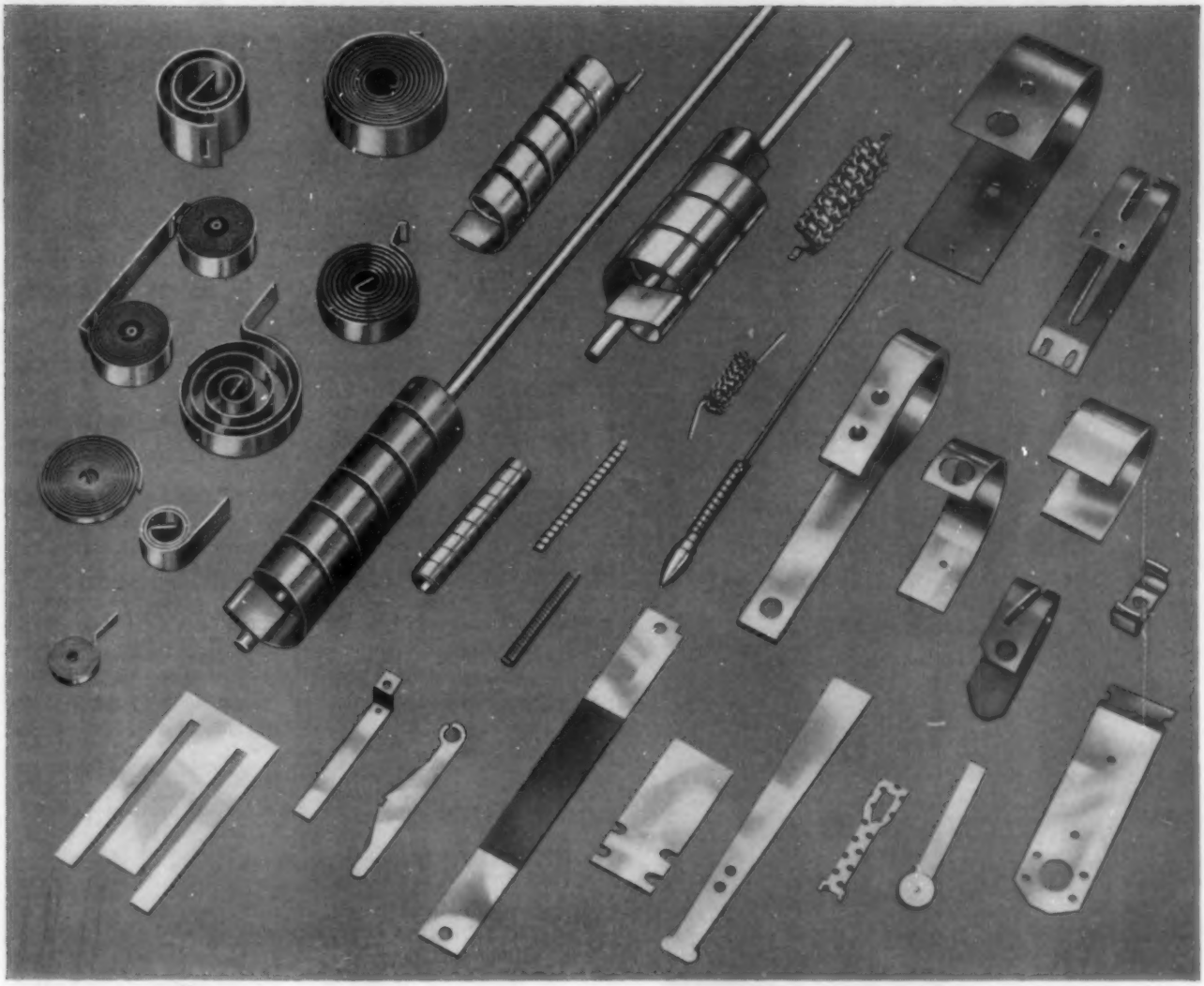
The reason . . . years of Sears experience proves KLIXON Protectors can be depended upon to provide positive protection and extend life of motors.

Should a motor become dangerously overheated due to overloads, stalled rotor or other causes, the KLIXON Protector snaps the power "off". If an automatic type of protector is used, it restores the motor to service automatically as soon as a safe working temperature is regained . . . or if a manual reset type of protector is used, the motor will remain "off" until manually restored.

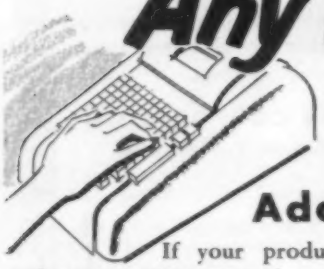
You, too, can keep motors in your equipment operating safely under adverse conditions, reduce service calls and repairs by specifying and using KLIXON protected motors. The additional cost is low, pays for itself over and over by reducing motor burnouts.

KLIXON

METALS & CONTROLS CORP.
SPENCER THERMOSTAT DIVISION
904 FOREST STREET, ATTLEBORO, MASS.



Any way you Figure it...



GENERAL PLATE TRUFLEX®
Thermostat Metals and Assemblies
Add up to Performance and Economy

If your products require temperature control . . . indication or compensation, General Plate TRUFLEX thermostat metals and fabricated elements and assemblies give you reliable, accurate performance and at the same time *cut your costs.*

Here's why — Advanced General Plate production methods coupled with the best equipment available insure positive consistency in thermal and mechanical performance and maintain close dimensional tolerances. Every lot, whether it is 10 pieces or 10,000, is a duplicate of the original, thus eliminating rejects and costly adjustments in assembly.

General Plate TRUFLEX fabricated elements and assemblies ready for installation in your products are engineered and manufactured to your exact specifications. You get accurate and consistent performance, because every order comes to you a faithful duplicate of the original. Costly fabrication problems . . . needless expense for special calibration equipment . . . and time consuming assembly adjustments are eliminated.

General Plate TRUFLEX thermostat metal and assemblies are made to meet your specific requirements for temperature range, electrical resistance, corrosion resistance, etc. If you prefer to make your own elements, General Plate will produce TRUFLEX thermostat metal strip to your material specifications. Write for TRUFLEX thermostat metal catalog and engineering assistance.

You can profit by using General Plate Composite Metals!

METALS & CONTROLS CORPORATION

GENERAL PLATE DIVISION

14 Forest St., Attleboro, Massachusetts

"Nothing can go wrong with Roto-Lock performance"

Says Elgin Metal Casket Company

Roto-Lock operation is simple: Serrated, tapered cam engages latch — draws panels tightly together when turned by crank or other hand tool.

Simmons Roto-Lock Fasteners are used by Elgin Metal Casket Co., of Elgin, Illinois, to give its Permaseal Caskets a perfect hermetic seal against air and water. Drawn down with a pressure of up to 1500 lbs., Roto-Lock guarantees an absolutely tight seal and strength far beyond requirements.

President E. B. Stewart of Elgin says: "Roto-Lock worked out particularly well because of the simplicity of its construction, and the fact that it was a lock already in a housing which could readily be sealed. Functionally the lock is very good since it pulls the lid down with ease and is a quick-operating mechanism. In other words, *the locking and sealing operation can be accomplished quickly and easily in a matter of seconds.* Since the whole locking and sealing mechanism contains only one moving part, *there is nothing that can go wrong with the performance of the lock.* Of course, this is important since mal-function at a funeral service would be a serious matter."

and there's a Roto-Lock application to improve your product

Roto-Lock, which makes butt or right-angle joints quickly, is finding wide application in portable shelters, air freight and cold storage shipping containers, walk-in coolers, demountable furniture and scaffolding. It fastens in any misaligned or semi-open position and recesses completely into panels. *Wherever* demountability is important, there's a Roto-Lock application.

Write today for our 36-page catalog. It's filled with applications of Roto-Lock and Simmons' four other special fasteners engineered to improve products and reduce assembly costs.

SIMMONS FASTENER CORPORATION
1751 N. Broadway, Albany 1, New York

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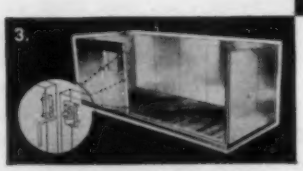
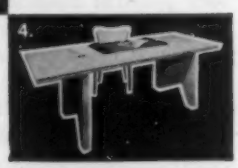
QUICK-LOCK · SPRING-LOCK · ROTO-LOCK · LINK-LOCK · DUAL-LOCK

FASTENERS WITH USES UNLIMITED





Some applications of Roto-Lock:

1. Portable Shelter
2. Partition
3. Demountable Refrigerator Unit
4. Demountable Desk

DU PONT
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PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

NO. 3 — 1955

Lightweight, Colorful Parts in Air-Conditioning System Molded of Du Pont "ZYTEL"* Nylon

Extruded Du Pont LUCITE® is specified for well-engineered lighting effects

LUMINOUS ceilings and modular panels of "Lucite" acrylic resin can be fabricated in many beautiful designs. Extruded sheets of "Lucite"—flat, corrugated, or formed—make durable, permanent, and efficient light-diffusing ceilings. Panels are extruded in widths of over 4 feet in clear or translucent white colors

Large 4 x 4 foot modular unit of extruded "Lucite". This unit transmits shadow-free light without glare. Panels of "Lucite" are available in many sizes—and in both clear and translucent colors.

which faithfully and efficiently transmit a comfortable light of low brightness.

"Lucite" transmits optimum light yet cuts down glare. It has excellent impact strength and maintains its original color. Clear and translucent white "Lucite" is stable in direct outdoor sunlight—makes an ideal material for glazing, outdoor lighting fixtures, and skylights. Fabrication is economical; maintenance is easy.

Extruded "Lucite" is now available to design engineers in increasing quantities. Use the coupon on the back of this page for complete information on beautiful, long-lasting Du Pont "Lucite".

"Zytel" nylon is precision molded in intricate shapes requiring no secondary finishing

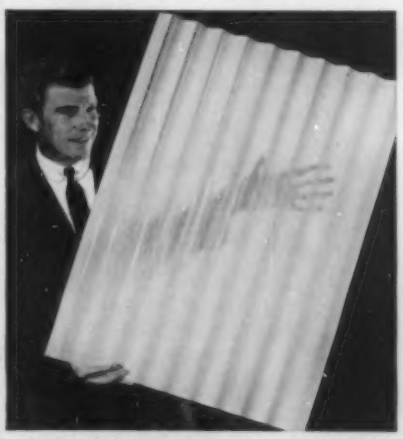
DU PONT "Zytel" nylon resin is being used throughout this new automotive air-conditioning system—for air deflector hoods, recirculated air intake grilles, air director shutters and grilles, and base units. "Zytel" gives these components many advantages over former units. Sweating, which was a major problem with the materials formerly used, is now eliminated through the use of "Zytel".

This engineering material is strong—extremes of heat, cold, and moisture don't affect its usefulness. Toughness is an important factor with the deflector hoods and air directors, which are handled and adjusted frequently. Moreover, "Zytel" damps vibration, operates quietly, assures long service life.

Production Economies

Substantial production economies are also possible. Through precision injection molding, mass production of these intricately shaped parts is achieved. Parts made of "Zytel" need no secondary machining or finishing. Color can be molded in. There are no plated or painted surfaces to peel or chip. The smart appearance of these parts demonstrates how "Zytel" performs both functionally and decoratively.

This air director hood assembly molded of Du Pont "Zytel" nylon resin is tough—frequent handling won't damage it. Molded by Bolta-Carpart, Inc., Owosso, Michigan.



Corrugated extruded sheet of "Lucite" for light-diffusing ceiling. "Lucite" has excellent durability . . . maintains its beauty and original color indefinitely.

Air director and shutter assembly. These molded parts of Du Pont "Zytel" need no machining or finishing operations.

Expanding Use

"Zytel" and the other Du Pont engineering materials are finding an ever expanding market in the automotive industry. Their unique combination of prop-

OVER

*"Zytel" is the new trade-mark for Du Pont nylon resin.

DU PONT
REG. U.S. PAT. OFF.

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

NO. 3 — 1955

"Zytel" (*continued*)

Molded parts of "Zytel" nylon resin are both functional and decorative. Colors are molded in—there are no painted or plated surfaces to peel or chip. Parts for this air-conditioning unit are molded by Bolta-Carpart, Inc., Owosso, Michigan.

erties enables automotive engineers to design parts that not only give improved performance, but also afford substantial savings in production and assembly costs as well. For complete information on these Du Pont engineering materials, clip and mail the coupon below.

Investigate Du Pont engineering materials in your product development programs

ONE of the family of these versatile engineering materials is often a key factor in product improvement or new design.

The wide range of properties available with "Alathon"* polyethylene resin, "Lucite"* acrylic resin, "Teflon"* tetrafluoroethylene resin, and "Zytel"† nylon resin are helping solve industrial design problems.

NEED MORE INFORMATION?

CLIP THE COUPON for additional data on the properties and applications of these Du Pont engineering materials.

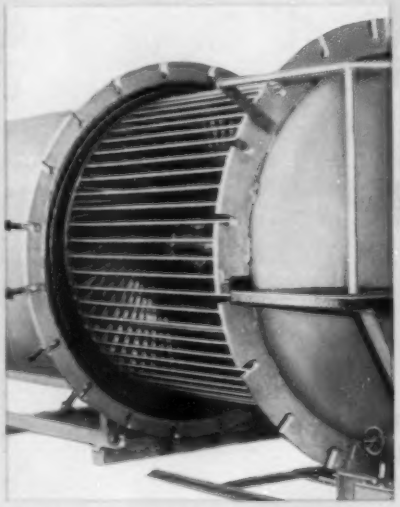
New dyeing machine has bushings of Du Pont TEFLON® to resist high heat and pressure

RECENTLY, a new machine called the "Barotor" was developed for dyeing synthetic fabrics. The "Barotor" improves the dyeing of synthetics by utilizing high temperatures and pressures. The designers were faced with the problem of choosing a material to be used for the bushings which carry the many stainless steel cross bars. These bushings could not be affected by the dyeing process, and should be able to function without lubrication.

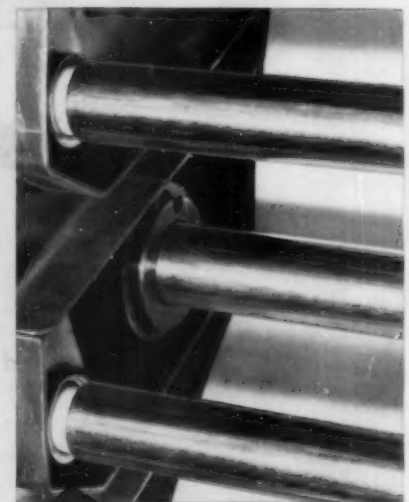
"Teflon" Solves Problem

Bushings of "Teflon" tetrafluoroethylene resin were the answer. These bushings are unaffected by the high operating temperatures of the "Barotor" and the 25 lbs. per square inch pressure used. The corrosive chemicals in the dye solution can't corrode these bushings, as "Teflon" is chemically inert. As this unique engineering material is self-lubricating and has a very low coefficient of friction, the problem of lubrication was eliminated. Wear on both the bushings and the cross bar was minimized. Result: Frequent replacement of parts is eliminated, and a substantial saving of time and money is achieved.

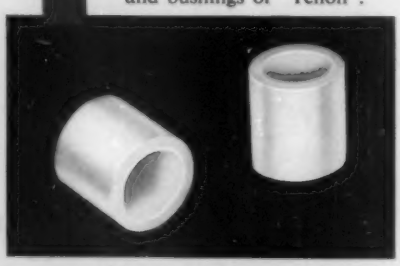
"Teflon" is another in the Du Pont family of engineering materials which has a tremendous potential in the textile industry. For additional data on any of these Du Pont engineering materials, fill out the coupon below at the left.



The new "Barotor" for dyeing synthetic fabrics uses heat- and pressure-resistant bushings of "Teflon" . . . gives smooth operation despite corrosive chemicals in dye solution.



Close-up of "Barotor", showing stainless steel cross bars and bushings of "Teflon".



Bushings of Du Pont "Teflon", formed by economical extrusion techniques.

E. I. DU PONT DE NEMOURS & CO. (Inc.) POLYCHEMICALS DEPARTMENT
Room 104, Du Pont Building, Wilmington 98, Delaware.

Please send me more information on the Du Pont engineering materials checked: ☐ *"Zytel";* ☐ *"Alathon";* ☐ *"Teflon";* ☐ *"Lucite". I am interested in evaluating these materials for:*

NAME _____ POSITION _____

COMPANY _____

STREET _____

CITY _____ STATE _____

TYPE OF BUSINESS _____

*"Alathon", "Lucite", "Teflon" are registered trade-marks of E. I. du Pont de Nemours & Co. (Inc.)
†"Zytel" is the new trade-mark for Du Pont nylon resin.

. . . Backed by Wide Application Experience

As manufacturers of *diversified* industrial equipment, Allis-Chalmers has been called upon to solve control application problems in practically every industry. This specialized experience in coordinating power utilization is *yours* when you specify Allis-Chalmers control.

The Allis-Chalmers line includes control for every condition of motor operation. Functions include full or reduced-voltage starting, acceleration, speed control, reversing or non-reversing, and dynamic braking. Built into Allis-Chalmers control is the type and degree of protection dictated by the application. Controls are available in general-purpose and special enclosures.

A-4587

For help on a specific control application, call your Allis-Chalmers representative. His recommendations are backed by Allis-Chalmers engineering departments . . . by experience gained in solving thousands of control problems . . . by complete research and testing facilities.

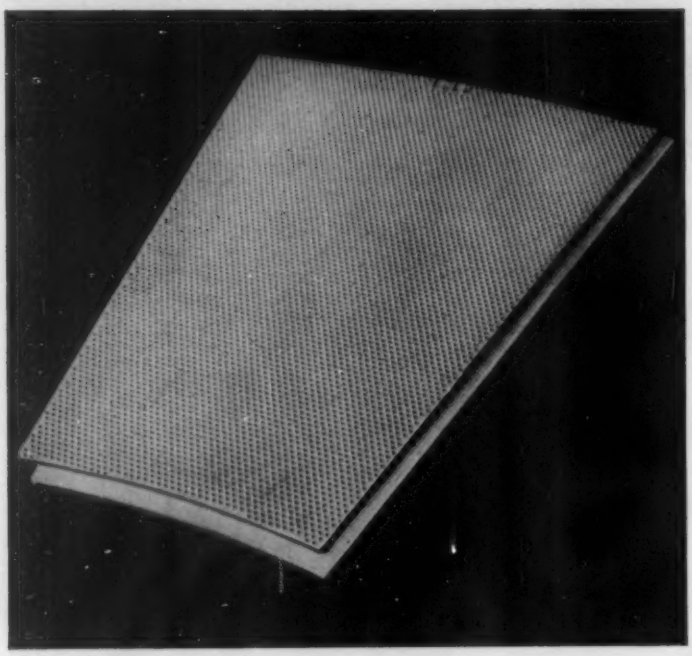
ALLIS-CHALMERS

MILWAUKEE 1, WISCONSIN

Now They Are Mass Produced

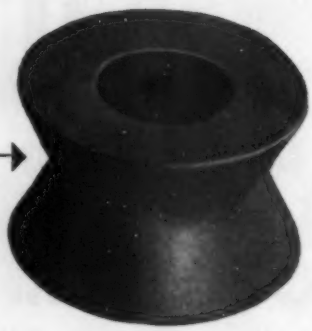
by HAYNES Investment Casting

Trade-Mark



IMPROVED DESIGN AND MATERIAL—The tiny needle-sharp points covering this plate must resist severe abrasion. Machined points used to wear out frequently because they were pyramidal in shape and highly susceptible to erosion. HAYNES investment casting made it possible to cast the points in a more stable conical shape from a hard, wear-resistant alloy. Life has been increased by 5 to 12 times.

EXCELLENT SURFACE QUALITY—For sanitary reasons, not even the smallest crevice can be tolerated on this cream separator part. Because of the high quality of HAYNES investment castings, it was found that the intricate part could be manufactured on a production basis with a minimum of imperfections showing up during the final polishing operations. This eliminated a great deal of wasted time, work, and metal.



NO MORE MACHINING—HAYNES investment casting eliminated the job of machining these rollers. Service conditions require that the rollers be made of a special alloy which is difficult to machine. They must resist rusting and the cutting action of wire passing over them under tension. The rollers give excellent service life and there are no more machining problems.

HAYNES investment castings can solve some of your own production and design problems. For more information, contact the nearest Haynes Stellite Company office listed below.

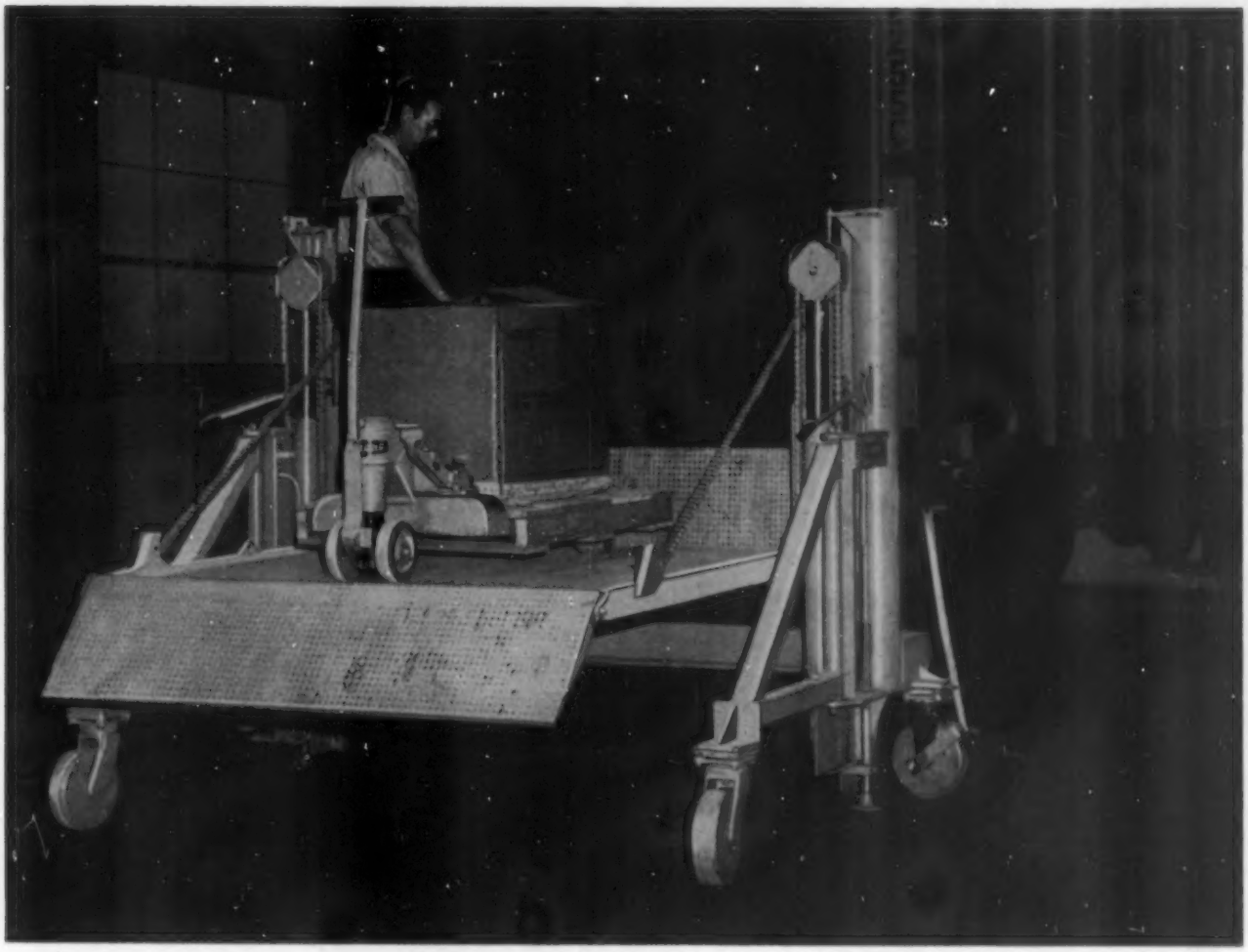
"Haynes" is a registered trade-mark of Union Carbide and Carbon Corporation.

HAYNES INVESTMENT CASTINGS

Trade-Mark

Sound, dense, high-strength parts available in cobalt-base alloys, nickel-base alloys, iron-base alloys, stainless steels, and alloy and carbon steels.

Haynes Stellite Company
A Division of
Union Carbide and Carbon Corporation
UCC
General Offices and Works, Kokomo, Indiana
Sales Offices
Chicago — Cleveland — Detroit — Houston
Los Angeles — New York — San Francisco — Tulsa



The Porta-Dock, produced by the Raymond Corporation, Greene, New York, can easily load and unload large over-the-road trailer trucks such as this. A remote-control, one-man operated elevating platform, it is used where no loading platform or facilities exist. Easily moved, it can be folded into a compact unit.

Heavy-duty Morse Cable Chains provide the tremendous strength necessary to support the Porta-Dock platform from both sides. Morse Roller Chains run over the sprockets at the top of the rams, to lift the platform. The two rams are synchronized so that the platform is level even when carrying off-center loads.

New portable dock relies on Morse equipment for heavy-duty service

When the Raymond Corporation first designed their new portable elevating platform, they found that Morse equipment ideally suited their power transmission needs. Why? Because Morse Power Transmission equipment is noted for meeting the most difficult requirements, and performing efficiently in every operation.

Morse Power Transmission Products can be depended upon to give the utmost service in this, as in any other application. Designed to meet the rigid requirements of industrial applications, they offer trouble-free service, and freedom from maintenance; reduce machine downtime to a minimum.

Let us show you how the complete line of Morse Power Transmission Products can help you. There are 24 precision-built products to serve you, with a wide range of sizes and types. In addition, we have expert application engineers available to work with you on your power transmission needs. Write today: MORSE CHAIN COMPANY, INDUSTRIAL SALES DEPT., ITHACA, NEW YORK.

MORSE B-W **CHAINS, CLUTCHES, AND COUPLINGS**

LESS TORQUE

In leather—NATIONAL MICRO-TORC TRADEMARK

Lowest torque • Highest lubricity • No measurable leakage
Runs cool, lasts longer • Sealing lip stores oil

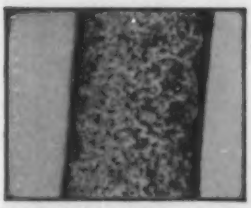


Fig. 1. National Micro-Torc Oil Seal. Oil cannot pass through elastomer coated side. Inner body retains natural porosity for "oil storage".

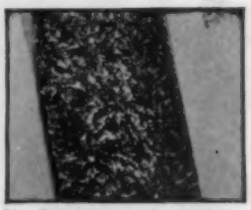


Fig. 2. Leather seal completely impregnated with rubber. Natural porosity of leather is destroyed by intense impregnation.

Shaft Size	Break Away Torque		Running Torque	
	Conventional Leather	Micro-Torc	Conventional Leather	Micro-Torc
1.500"	39 oz-in	7 oz-in	60 oz-in	56 oz-in
2.937"	126	39	253	164
3.812"	95	49	287	207

Fig. 3. Breakaway and running torque measurements, National Micro-Torc vs. conventional leather oil seals.

	NMB Micro-Torc		Completely Impregnated Leather Seal	
Test Conditions Shaft Speed: Shaft Size: Shaft Runout, TIR: Oil Temperature:	2200 RPM 3.875" .003" 200° F.		800 RPM 2.750" .004" 165° F.	
Test No.	C-1642	C-1643	D-100	D-101
Total Running Time:	1017 hrs.	1017 hrs.	108 hrs.	108 hrs.
Condition after Test: Sealing Member: 180° Bend Test:	Flexible Surface Cracks	Flexible Surface Cracks	Very Stiff Deep Cracks	Very Stiff Deep Cracks

Fig. 4. Service life test results. National Micro-Torc Oil Seals vs. completely impregnated leather seals.

Revolutionary new Micro-Torc Oil Seals, exclusively from National, employ a leather sealing member coated on the surface with a high lubricity elastomer. This coating not only reduces torque as much as 80% but effectively prevents lubricant leakage. Since the coating is applied to the outer surface of the sealing member only, the body of the sealing lip retains its natural porosity to store oil for periods of semi-starved operation. (Figure 1.)

The appreciable superiority of Micro-Torc over completely impregnated leather seals (Figure 2) is shown at left. In addition to a marked reduction in torque (Figure 3), service life of Micro-Torc seals was test-proven to be up to 10 times the life of completely impregnated seals, and 2 to 3 times that of wax or resin impregnated seals. (Figure 4.)

In dry-running life tests Micro-Torc seals operated for 100 hours at 1,350 rpm *with no lubrication*. No squealing or sloughing was experienced, and all Micro-Torc seals remained flexible and operative.

National Micro-Torc Oil Seals are unaffected by many industrial fluids and lubricants which attack ordinary leather seals. They are recommended for application where temperatures do not exceed 200° F, shaft speeds are not over 2,000 fpm and runout is not greater than .005 indicator reading.

New! NATIONAL TORQUE METERS

New National Torque Meters provide a simple, accurate way to measure breakaway torque of oil seals. The meters are rugged, compact, easily portable, ideal for production or laboratory use. They have an easy-acting self-centering chuck for accurate seal holding, and use a simple taper-fitting test shaft you can make up in a matter of minutes. The Meters are designed for utmost simplicity, and with them unskilled personnel can make accurate torque readings with but a few moments training.

Two sizes: Model 415 fits seals up to 6" dia.; 15 lbs. in. torque. Model 845 fits seals up to 8" dia.; 45 lbs. in. torque.

Meters measure 13" long x 10" wide x 11" high. Weight 27 lbs. Sturdy fiber carrying case can be furnished.

with NATIONAL OIL SEALS

In synthetic rubber—SYNTECH®

Low torque • Rubber-covered or ground O. D. • Long life
Zero leakage • Unaffected by most industrial fluids

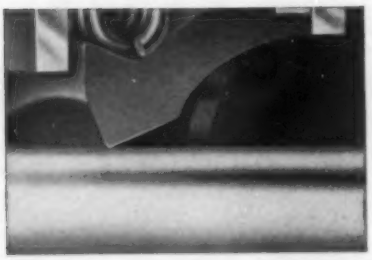


Fig. 5. Cross-section, typical National Syntech sealing lip. Note limited point of contact between seal and shaft.

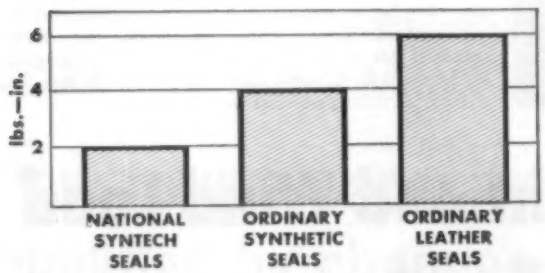


Fig. 6. Torque, Syntech vs. conventional synthetic rubber and leather oil seals. Seals tested on same shaft, under identical conditions.

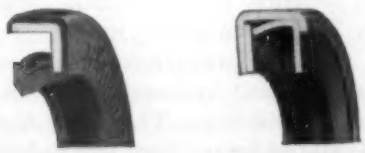


Fig. 7. (Left) National Syntech Rubber-Covered O.D. (Right) National Syntech with machine-ground steel O.D.

NATIONAL
OIL & GREASE SEALS
O-RINGS SHIMS

Developed and introduced by National in 1946, National Syntech seals are among today's most widely used synthetic rubber oil seals. Their performance and dependability have been proven in thousands of commercial applications.

Syntech seals are particularly designed for higher speed, higher temperature applications where torque must be held to the absolute minimum. They feature an exclusive sealing lip design (Figure 5) which insures minimum contact between lip and shaft, yet provides zero leakage over a long service life. The marked difference in torque between Syntech and ordinary leather seals can be as much as 200%, as shown in Figure 6.

National Syntech Oil Seals are available in a wide selection of types and sizes, including seals with rubber covered or machine-ground peripheries (Figure 7) spring-tensioned or spring-less, or with twin or triple lips for special applications.

Call in a National Applications Engineer

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MORE INFORMATION?

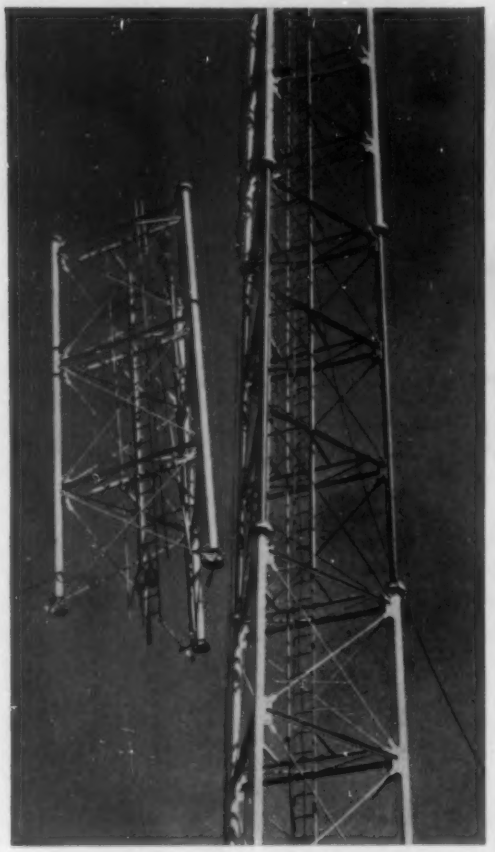
NATIONAL MOTOR BEARING CO., INC.
DEPT. A., REDWOOD CITY, CALIFORNIA

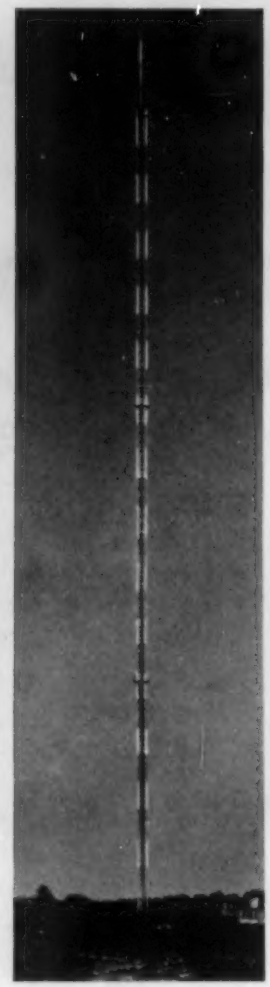
Please send complete information, illustrated technical details on
____Micro-Torc seals ____Syntech seals ____Torque Meter

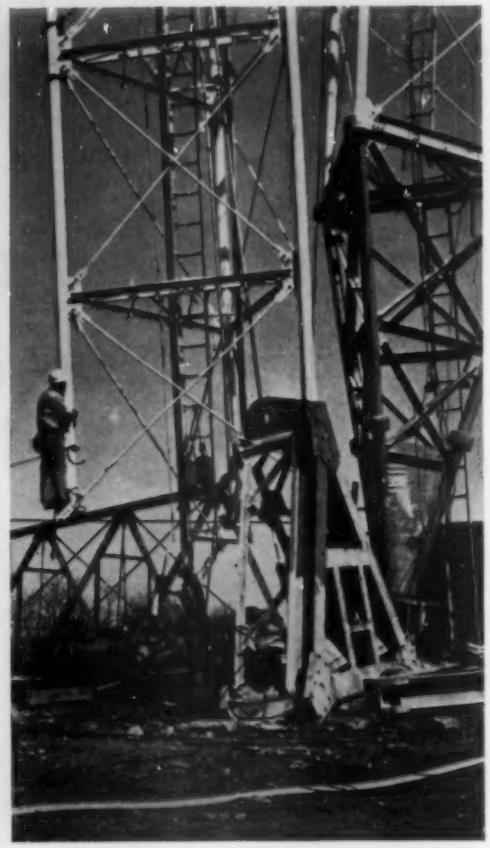
Name_____
Company_____
Street_____
City_____ Zone____ State_____

3310

Mayari R makes it lighter... stronger... longer lasting







Antenna tower for Station WCAU-TV, Philadelphia, designed and erected by Dresser-Ideco Company. Excellent weldability, together with its yield point of 50,000 min for diameters 4½ in. or less, and 45,000 min for diameters over 4½ in. to 8 in., made the use of Mayari R economical. Tower was assembled in 30-ft sections on ground, which were then hoisted into position. Note guy cables, anchored at 270-ft, 570-ft and top levels.

Mayari R Legs Cut Weight and Wind Load on 951-ft TV Tower

Pointing nearly a fifth of a mile into Philadelphia's skies, WCAU-TV's antenna tower is a recent feather in the cap of Dresser-Ideco Company, Columbus, O., who designed and built it. Ideco's engineers used solid steel rounds of Mayari R for the tower legs, and gave these reasons for their selection:

First, high-strength Mayari R permitted leg sections of smaller diameter than would have been possible with structural carbon steels. This lowered the deadweight, which in turn reduced the foundation costs and simplified handling during erection.

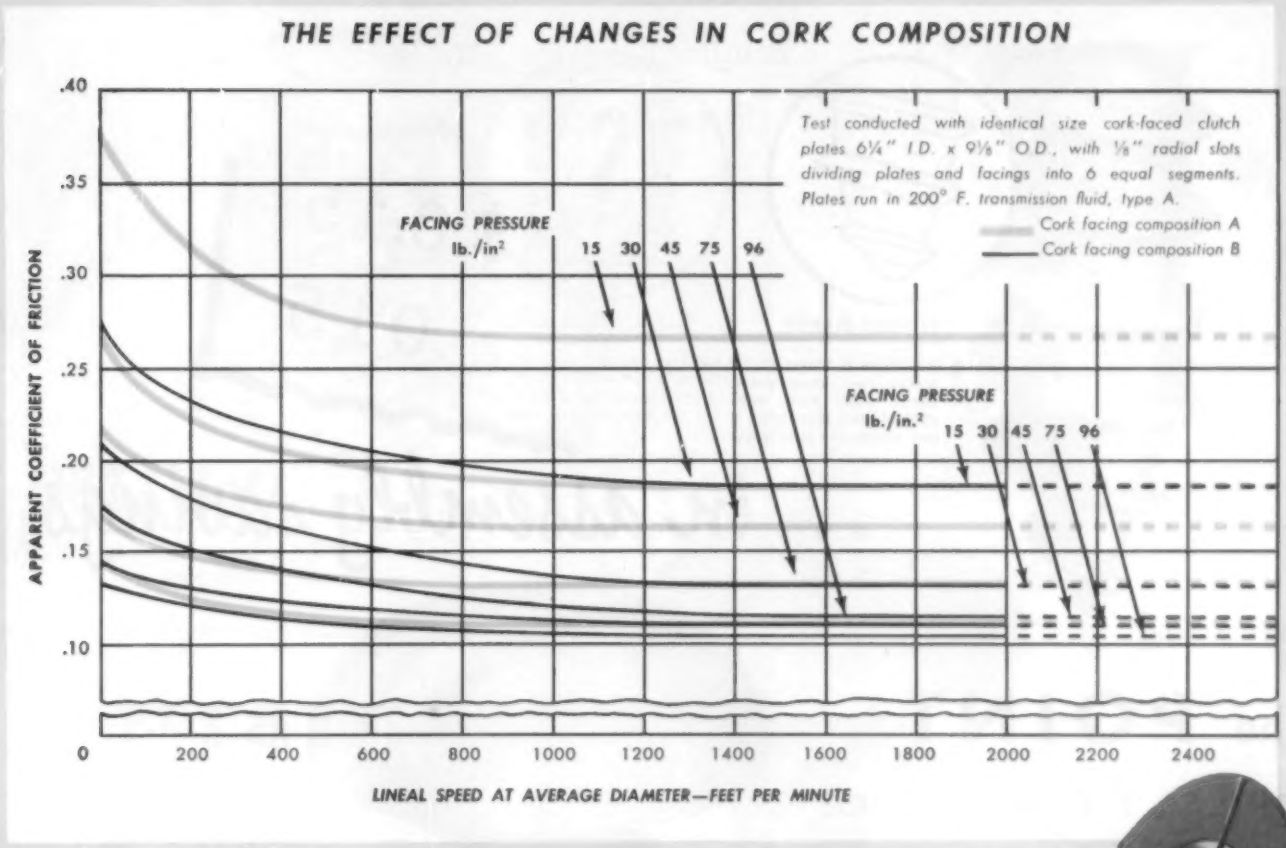
Second, the slimmer legs put up less resistance to the wind, reducing the loads imposed on the tower by wind pressure. The leg rounds varied in diameter from 7 in. down to 2½ in.

Because of its high strength-to-weight ratio, Mayari R has been used by hundreds of tons in structural work of this type. This same feature makes it ideally suited for such projects as bridges and buildings, construction equipment and bus bodies, as well as dozens of other tough-duty applications. Catalog 353 tells the story, and a copy is promptly yours for the asking.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL


THE EFFECT OF CHANGES IN CORK COMPOSITION
Test conducted with identical size cork-faced clutch plates 6¼" I.D. x 9⅛" O.D., with ⅛" radial slots dividing plates and facings into 6 equal segments. Plates run in 200° F. transmission fluid, type A.
Cork facing composition A
Cork facing composition B
FACING PRESSURE lb./in²
15 30 45 75 96
FACING PRESSURE lb./in.²
15 30 45 75 96
APPARENT COEFFICIENT OF FRICTION
.40
.35
.30
.25
.20
.15
.10
0
200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400
LINEAL SPEED AT AVERAGE DIAMETER—FEET PER MINUTE

CORK CLUTCH FACINGS:

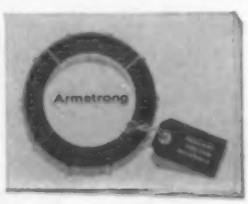
How torque capacity can be modified by changes in cork composition

Cork-compound friction materials as a class have unusually high torque capacity. Equally important to designers, however, is the fact that this capacity can be widely modified by changes in the cork composition.

Cork clutch facings can be compounded with a variety of resins, fibers, and rubbers. As a result, there is a wide range of cork compounds available, each offering somewhat different torque capacity. Within this range, designers can usually find a facing material that will deliver the exact performance required.

The chart above illustrates how changes in clutch capacity can be produced by modification of the cork compound used as facing. The values shown were developed by clutch plates identical in all respects except for the facing compound. The frictional patterns of both are similar, because the metal plates were of the same design and size. But the apparent coefficients of friction produced by composition A are higher than those produced by composition B.

This wide range of torque capacities is only one of many unique advantages which cork-compound friction materials offer. For more information on the performance versatility of these materials, send for a copy of our new booklet, "Armstrong Resilient Friction Materials." Write on your letterhead to Armstrong Cork Co., Industrial Div., 7204 Irvin Street, Lancaster, Pennsylvania.

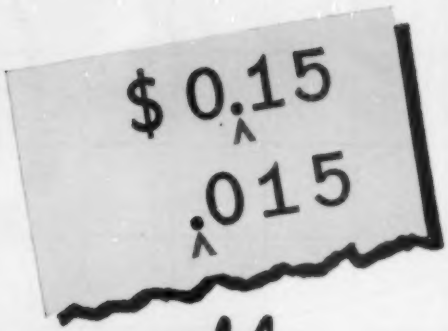


Armstrong FRICTION MATERIALS

. . . used wherever performance counts

IS POINT BLUNT?

P-K Type A Sheet Metal Screws have sharp gimlet points. Start easy, drive straight, even when holes in two sheets are misaligned.



. . . in assembly savings

the **POINT** makes the difference

A properly planned saving of 15 cents per unit can fade to 1½ cents — or nothing — on the assembly line . . . unless the screws you use have the good points that assure quick starting and straight driving.

Bad points are hard to detect in the package, but your cost sheets and customer complaints will soon show their effects — job slowdown, parts spoilage, hidden weakness.

That's why P-K quality standards have been set so high — to make sure you get P-K Self-tapping Screws that are not only *pointed for savings*, but headed, threaded, and heat-treated with one purpose, to keep your assembly lines trouble-free.

Start making *planned* assembly savings pay off . . . talk to a P-K Assembly Engineer. Parker-Kalon Division, General American Transportation Corporation, 200 Varick St., New York 14.

DOUBLE LEAD THREADS?

P-K Type Z Self-tapping Screws have well defined taper. Screw stands erect in hole and double lead thread means quick, easy starting; forms secure mating threads.

PARKER-KALON®

IN STOCK . . . see your nearby P-K Distributor . . .

HOW MANY FLUTES?

P-K Type F Screws have five thread cutting flutes; easier to start, less torque in drive, cut clean threads all the way in.

per unit

P-K STANDARDS
make sure you get
SCREWS POINTED FOR SAVINGS

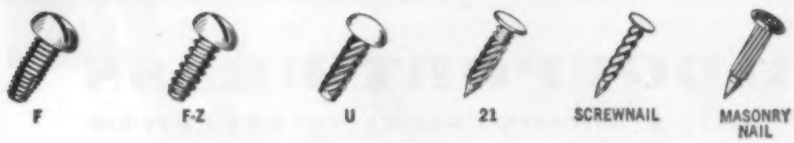
P-K design and quality standards protect you against the bad points shown and many others that will slow down assembly and cause parts damage. They don't "get by" P-K Inspectors — that's why *all* P-K Self-tapping Screws can be "Guaranteed First Quality."

IS PILOT TOO SHORT?

Pilots of P-K Type U Drive Screws are proper size and length to permit screws to start straight, drive straight.

The First originated by P-K . . . and First today . . . the leading choice for fastening economy

SELF-TAPPING SCREWS



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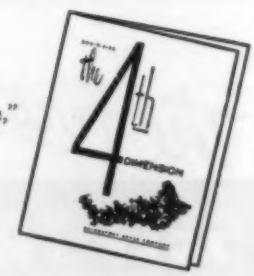
BRIDGEPORT'S HIGH I.Q. BRASS

means production savings

The right grain size can often mean the difference between a poor finish produced at high cost and a gleaming, lustrous finish made at substantial savings. This is one of the *High Inner Qualities* you can count on in Bridgeport sheet and strip brass. Bridgeport offers a *range of grain sizes* . . . can help you select the *right* one, combined with other *inner qualities,* to boost production and lower costs.

Our nearest sales office will be glad to show you how to profit with Bridgeport sheet and strip. Let us put Bridgeport *High I.Q.* to work for you today.

Bridgeport folder on grain size, "The 4th Dimension," will be sent to you on request.



BRIDGEPORT BRASS

COMPANY ♦ BRIDGEPORT, CONNECTICUT

Offices in principal cities. Conveniently located warehouses.
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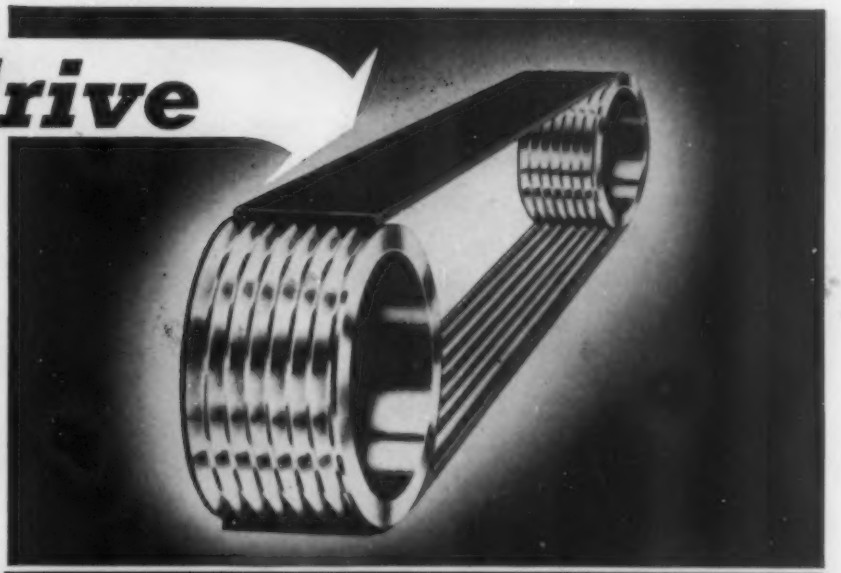
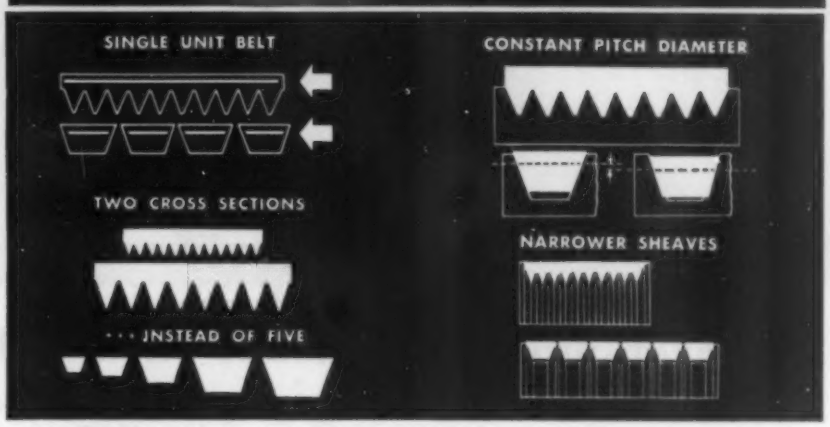
THIS NEW DRIVE SOLVES MANY OLD PROBLEMS

. . . R/M poly-v® drive



Here is Raybestos-Manhattan's answer to equipment designers' needs for an "ideal" belt drive . . . the Poly-V Drive . . . R/M's patented and completely new concept of power transmission. Poly-V Drive combines high V-groove grip with the strength and simplicity of flat belts in a single, endless rubber belt. A series of parallel V ribs molded lengthwise around the inside circumference mate precisely with the specially designed sheaves. No other belt drive offers comparable advantages for the improved design of new and existing power equipment.



SINGLE UNIT BELT

Uninterrupted strength member extends across full width of sheave. All parts of belt work together to give uniform pull. No more matching problems, or belt turn-over.

NARROWER SHEAVES . . . OR MORE POWER IN SAME SPACE

Width of Poly-V Drive is only ⅔ to ¾ of the width of standard multiple V-belt drives because Poly-V Belt has higher horsepower capacity per inch of width.

CONSTANT PITCH DIAMETER

Poly-V Drive eliminates sinking of belt in sheave grooves and maintains constant pitch diameter and speed ratio at *all* loads and runs smoother, cooler. There is less wear on belt and sheaves.

TWO CROSS SECTIONS INSTEAD OF FIVE

Instead of 5 V-belt cross sections, only two cross sections of Poly-V Belt, in appropriate widths, are required to cover every heavy-duty power transmission problem. This allows greater interchangeability and lower inventory of belts and sheaves.

poly-v DRIVES IMPROVE HEAVY DUTY POWER TRANSMISSION IN EVERY INDUSTRY

Ideal for manufacturers of equipment for agriculture, oil drilling, metal working, mining, wood working, paper, textiles, and other original equipment design applications. The outstanding advantages of Poly-V Drive have proved it to be the greatest advancement in power transmission drive design since the multiple V-belt! R/M engineers are prepared to give you every assistance in solving your power transmission design problems with Poly-V Drive, and will gladly furnish complete engineering data. Ask your R/M representative for additional information, or write for special bulletin #6638.

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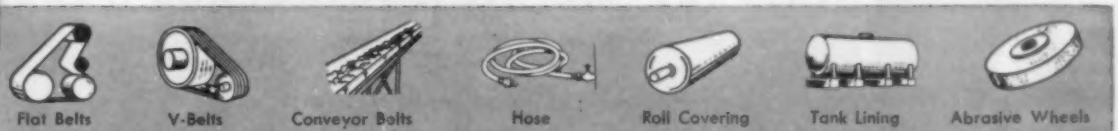
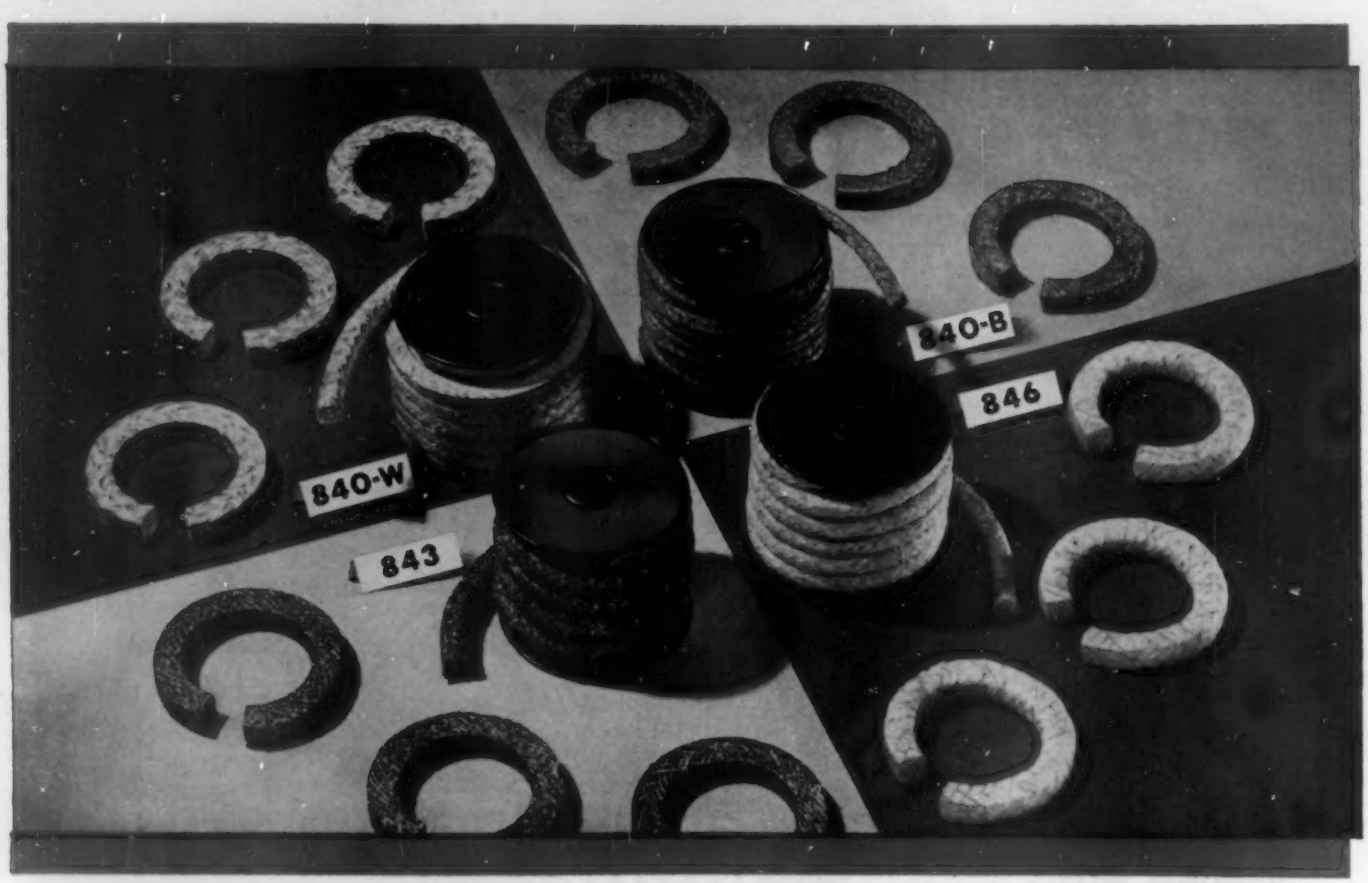
MANHATTAN RUBBER DIVISION — PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.



Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings
Asbestos Textiles • Packings • Engineered Plastic, and Sintered Metal Products • Bowling Balls

CALL ON R/M ENGINEERING SERVICE



OUTSTANDING PERFORMERS—R/M "TEFLON"* PACKINGS

If you are designing or making chemical handling equipment, you will want to be acquainted with these R/M "TEFLON" Packings that are giving such outstanding service on chemical pumps and valve stems.

In R/M Packing No. 843, "TEFLON" is combined with South African blue asbestos. Together they make a terrific pump packing—a sealing team you can count on to handle most acids and corrosives up to 220°F. The asbestos compensates for the high thermal expansion of "TEFLON" and makes lubrication saturation possible.

R/M Packings Nos. 846, 840-B and 840-W are for valve stems. No. 846 is an all-"TEFLON" braided packing that is unaffected by chemicals and solvents up to 500°F. It can always be recommended when the nature of the material being handled can not be revealed. For some applications the same sealing effectiveness can be obtained, however, with No. 840-B or No. 840-W . . . both of which contain asbestos. No. 840-B is ideal for use with corrosive and acids; No. 840-W with solvents and oils . . . and also where food contamination is a problem.

The complete R/M line includes packings and gasket sheets for use with air, gas, water, steam, oil, chemicals, solvents, food products, and hydraulic fluids. R/M also makes a wide variety of asbestos textiles. If you have requirements indicating any of these materials or products, feel free to call on R/M's specialized engineering service.

*Du Pont's trade-mark for its tetrafluoroethylene resin

For booklet shown, or other data, write, phone or wire:

PACKING DIVISION OR
ASBESTOS TEXTILE DIVISION
Raybestos-Manhattan, Inc.
Manheim, Pa.
Manheim 5-2211

R/M

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

Brake Blocks, Linings and Clutch Facings | Fan Belts and Radiator Hose | Mechanical Packings and Gaskets | Abrasive and Diamond Wheels | Industrial Drive Belts | Industrial and Automotive Hose

FOR HELP IN SOLVING YOUR PROBLEMS

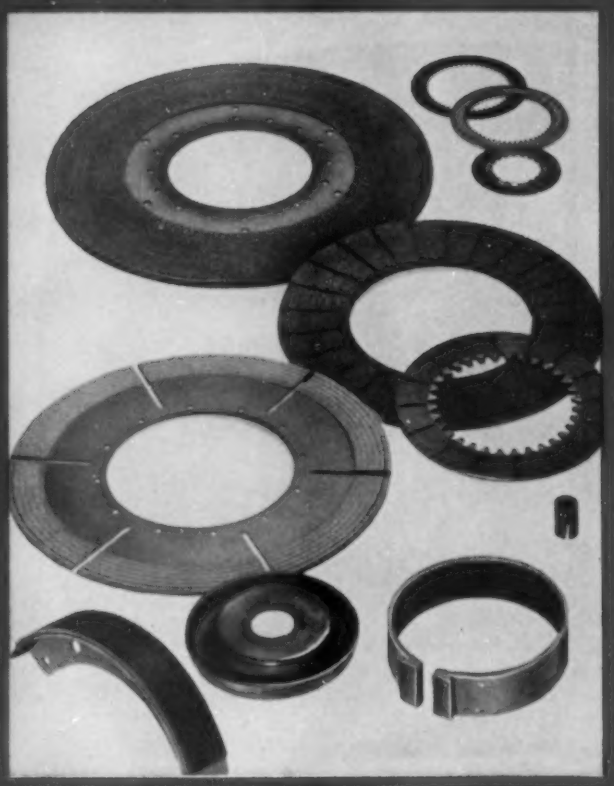


Photo Courtesy Link Belt Company

BONDING Friction Materials

The bonding of friction materials to other mating members is an art. Raybestos-Manhattan has spent more years than any other company acquiring proficiency in it, so the chances are good that if a bonding problem is facing you, R/M engineers have already faced it and solved it.

Unlike other manufacturers, R/M works with *all* kinds of friction materials. To be sure of completely unbiased advice on your problem, consult an R/M engineer now.

Write for your copy of R/M Bulletin No. 500. It's loaded with practical design and engineering data on all R/M friction materials.

EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
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R/M CONVEYOR BELTS

There is an R/M engineered conveyor belt for every design application . . . for portable and stacker conveyors, table and small parts conveyors, food belts, package conveyors, and heavy duty conveyors for mining and quarrying operations. In many cases, unusual design requirements have been met by exclusive R/M constructions. Where required, R/M will custom-engineer conveyor belts for special job conditions . . . for resistance to heat, acid, oils, and to avoid static or contamination. Let an R/M specialist work with you next time.

For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
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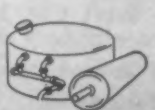
RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • No. Charleston, S.C. • Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Conveyor Belts



Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

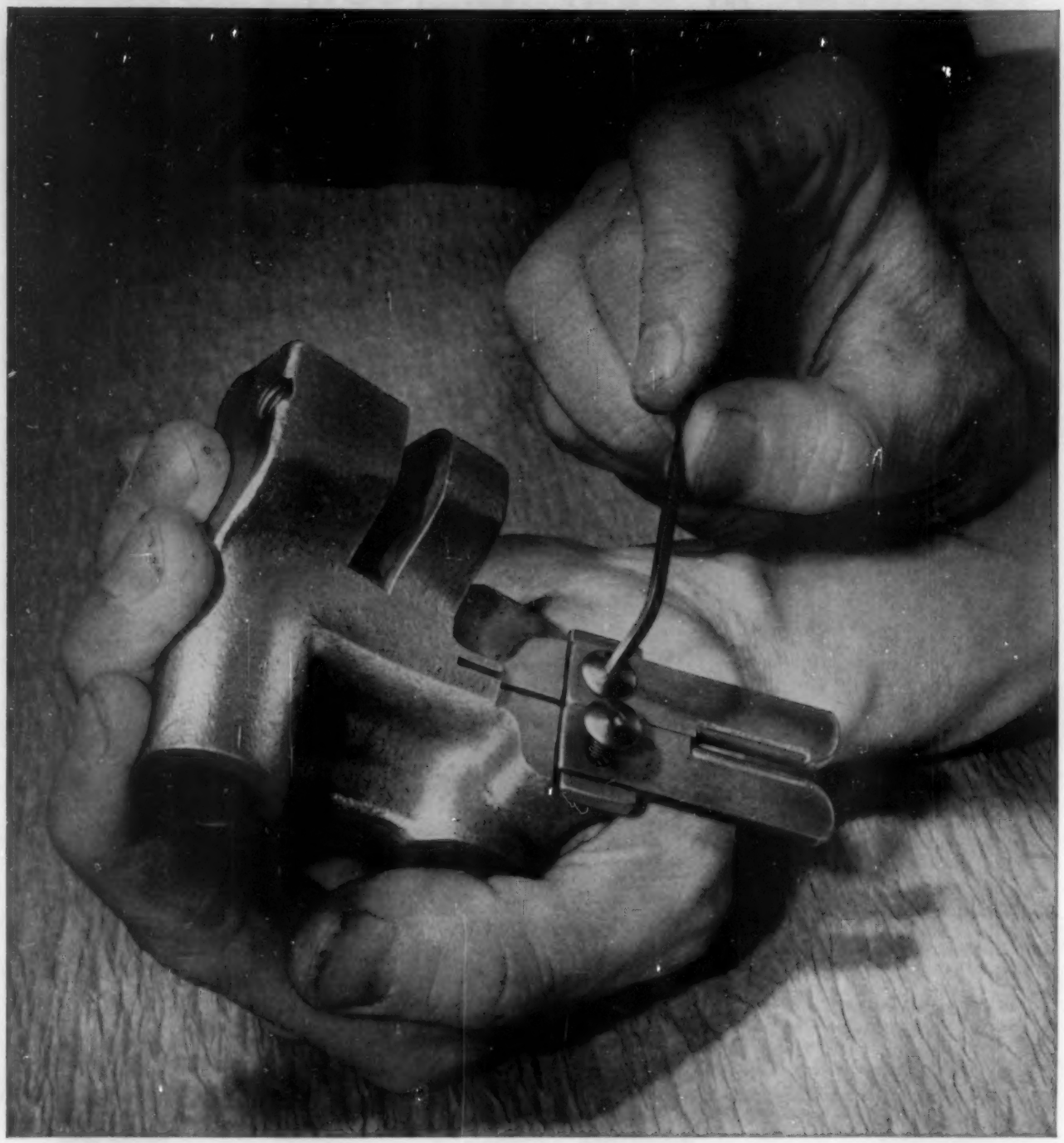
Asbestos Textiles

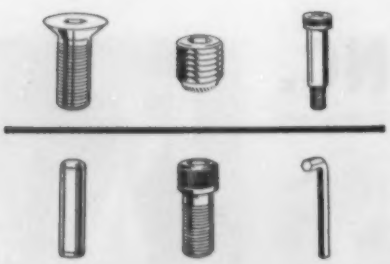
Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

R/M

UNBRAKO AT WORK

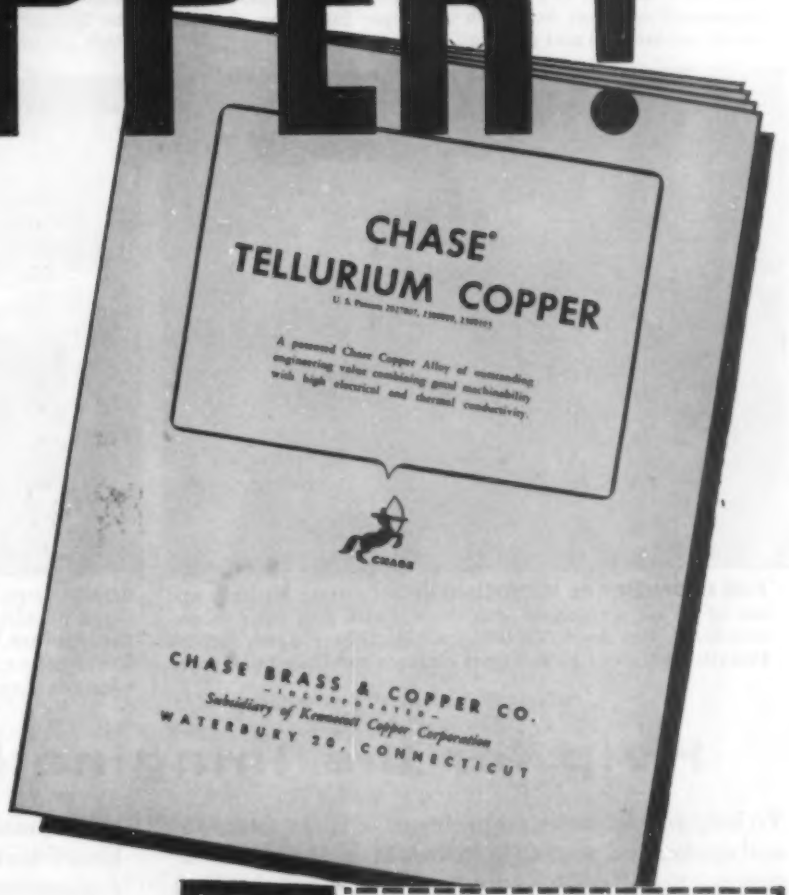




BUTTONING UP THE JOB PROPERLY. UNBRAKO Button Head Socket Screws, of course, provide a smooth, streamlined surface. They are strong, too. But equally important is the ease with which they can be inserted and withdrawn without marring the socket of the screw or the surface of the assembly. For the complete UNBRAKO story, see your authorized industrial distributor. Or write to STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

UNBRAKO SOCKET SCREW DIVISION SPS JENKINTOWN, PENNSYLVANIA

TELLURIUM COPPER!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A patented Chase Copper Alloy of outstanding engineering value combining good machinability with high electrical and thermal conductivity.
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Chase Tellurium Copper gives you the advantages of high conductivity *plus* good machinability.

Chase Tellurium Copper can be machined with tool speeds and settings similar to those used with Free-Cutting Brass, permitting high rates of production. But, unlike Free-Cutting Brass, Chase Tellurium Copper can be *hot worked* easily, and can be cold worked almost as extensively as pure copper.

For more information on Chase Tellurium Copper, check the coupon below.

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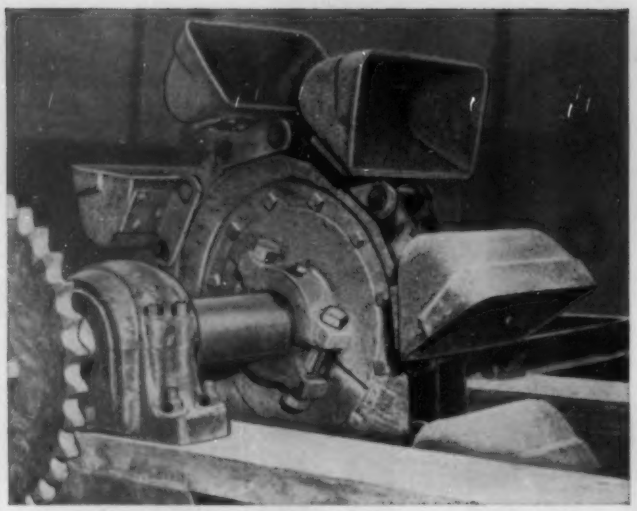
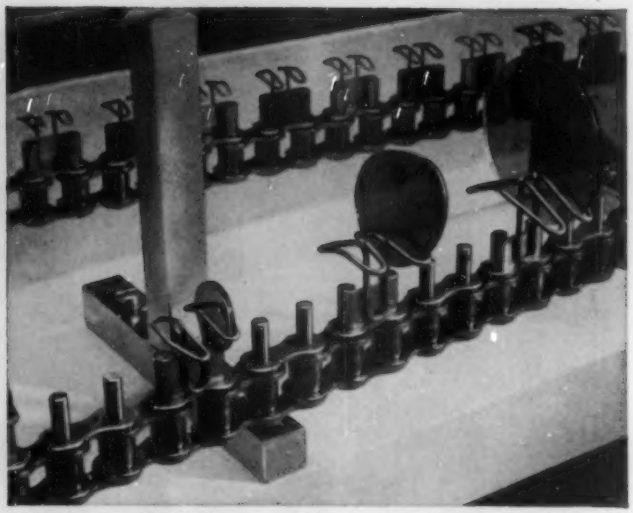
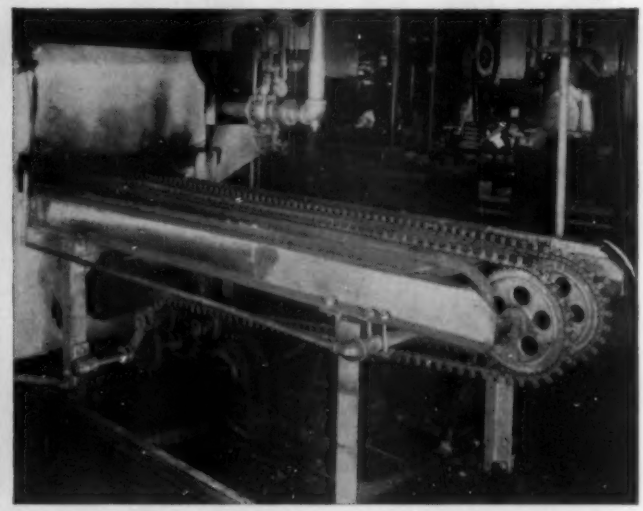


CUTTING MAINTENANCE for bucket elevators and heavy-duty conveyors took an imaginative solution by the CHAIN Belt Man and his engineering department. The answer...a segmental sprocket hub with a unique bolted-on rim that could be installed and replaced easily.



CONVEYING LENSES for glasses offered a tough problem. The CHAIN Belt Man solved it by the use of a roller chain with extended pins. Pins have removable clips which carry the lenses. The chain operates on its side and various size clips are interchangeable.

FOR ECONOMICAL HANDLING of hot cutting bits into and out of an oil tempering bath, the CHAIN Belt Man recommended a Rex Steel TableTop Chain. The rugged, smooth carrying surface of TableTop is ideal for handling small parts.



CONVEYING MATERIALS through an annealing oven isn't a tough problem, thanks to the complete chain line offered by CHAIN Belt. Heat and corrosion-resistant Rex® Stainless Steel Roller Chain with standard M-35 attachments provided a long-lasting, economical answer.

Help for the Imaginative Designer

To help you solve design problems of chain selection and application, your CHAIN Belt Man doesn't offer a trite solution. Rather, he applies a trained imagination to seek the best possible answer. For, in selecting and applying chains for drive or conveyors, the field is limited only by the experience and imagination of the designer.

Your CHAIN Belt Man has a complete line of chains, attachments and sprockets to draw upon...a broad background of experience and a home-office engineering staff to help him help you.

Where you need an unusual solution to a usual or unusual problem in cutting costs...improving machine performance...use the help offered by your CHAIN Belt Man. Call him or write CHAIN Belt Company, 4715 W. Greenfield Ave., Milwaukee 1, Wisconsin.

AT YOUR SERVICE
to help you with chain drives
and conveying applications
YOUR CHAIN Belt Man

CHAIN BELT COMPANY

District Offices in all principal cities

We put Hydraulic Cylinders on a reducing diet

RESULT:

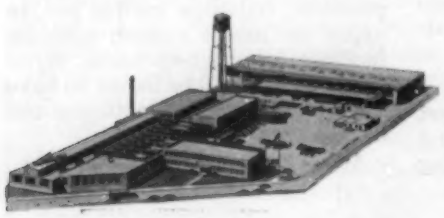
The New VICKERS® "Compact" HYDRAULIC CYLINDERS

For 2000 PSI Working Pressure

Everybody agreed that hydraulic cylinders were just too fat . . . took up too much space. So our engineers put them on a reducing diet. The result . . . these slim, powerful, "Compact" cylinders fit and work in spaces where the old type could not. It is part of Vickers long-time program of continuous improvement.

Among their many other features are: Multiple port positions. Spring-loaded synthetic-impregnated leather rod seal compensates for wear, assures long service. Piston seals are improved cup type. Tie rods are high tensile alloy steel. Adjustable integral hydraulic cushions are available. Comply with JIC standards. Conservatively rated for maximum working pressure of 2,000 psi. For further information, see Bulletin 54-68.

Waterbury Tool Division of Vickers Incorporated where "Compact" Cylinders are manufactured.



Ask for New Bulletin 54-68

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DIVISION OF SPERRY CORPORATION

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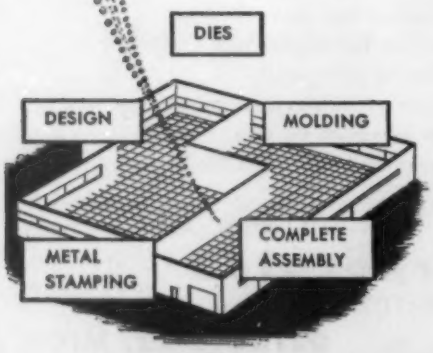
6950

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

custom-molded

Plastic Parts

—Sylvania's model facilities offer complete "one source" service



ONE production schedule . . . one delivery cycle—one responsibility! These are the conveniences you get with "one source" supply of plastic parts custom-molded for your product by Sylvania.

These are the Sylvania services which make it all possible: expert die making . . . automatic molding in thermoplastic and thermosetting materials . . . metal stamping and forming . . . complete assembly.

Whatever the nature of your products, Sylvania invites you to apply its model custom molding facilities to your own needs. Write or phone. We will be happy to have a representative meet with you and discuss your problems.

Write Department D-33S.

SYLVANIA

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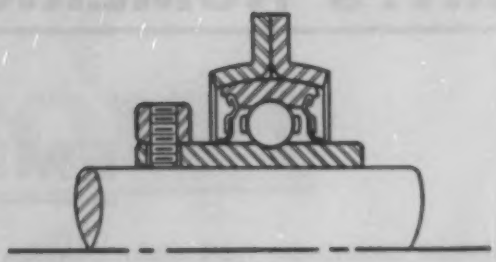
LIGHTING • RADIO • ELECTRONICS • TELEVISION • ATOMIC ENERGY

LOW COST is achieved with the use of an especially sturdy, pressed steel housing that combines strength and light weight, yet equipped with the same high quality precision bearing used in all Link-Belt ball bearing blocks.

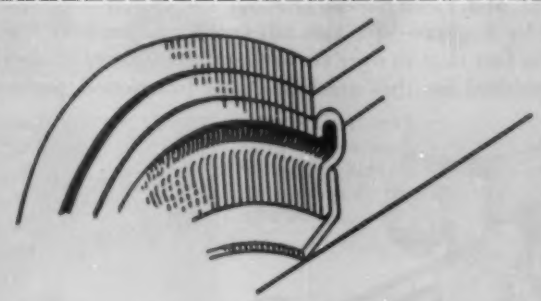


UNRESTRICTED SELF-ALIGNMENT. Aligning surface of housing is precision-coined to assure proper fit and support of bearing. Free-rolling action and full load capacity are maintained even with shaft misalignment.

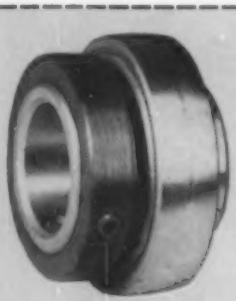
It's important

bearing differences

like these that add up to strength plus economy



MAXIMUM SEALING EFFICIENCY. Synthetic rubber lip-type seal, integral with the bearing, retains lubricant and excludes dirt . . . even in extremely dusty conditions. Greased at factory, bearing needs no further lubrication.



SINGLE-ROW, DEEP GROOVE BALL BEARING assures smooth operation and long life. Manufactured in accordance with the standards for the Anti-Friction Bearing Manufacturers Association BCO2 ball bearings.

They're all present only in this new, low-cost LINK-BELT ball bearing

HERE'S the kind of specialization you get in industry's most complete line of ball and roller bearing blocks. The wide-spread need for a low-cost bearing—offering precision, anti-friction bearing performance—led to development of the JPS-200. Bulk is minimized—unrestricted alignment and effective sealing characteristic of Link-Belt bearings are maintained. The result is a bearing that costs you less . . . yet can challenge any for efficiency in light-duty applications.

Every Link-Belt bearing is made to meet just such a specific need. Ask your Link-Belt office for Folder 2517 on the JPS series. Get Book 2550 for data on Link-Belt's complete line.

Low-cost series JPS-200 is part of industry's most complete line of ball and roller bearing blocks.

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,713

LINK-BELT

Ball and Roller Bearings

M.I.T.'s NUMERICALLY CONTROLLED

EMPLOYS LAST WORD

Saginaw's b/b Screws assure precision positioning with minimum power requirements

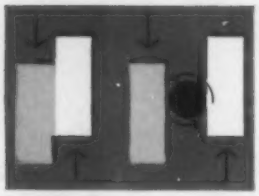
When this pioneering robot machine tool was under development at the Servomechanisms Research Laboratory at the Massachusetts Institute of Technology, one of the vital requirements was a method of automatically actuating and positioning the vertical, crosshead and table feeds with absolute accuracy and dependability—*without excessive power consumption.*

We are proud that M.I.T. engineers selected the *Safety ball/bearing Screw*—pioneered by Saginaw—for this advanced assignment. We are even prouder of the fact that in over two and one-half years of service, the screws we furnished for this machine have functioned perfectly.

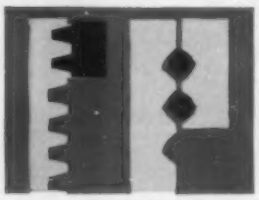
MILLING MACHINE

IN ACTUATION !

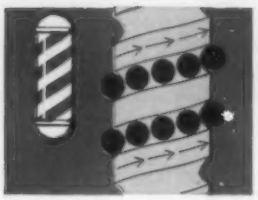
WHAT IT IS AND HOW IT WORKS:



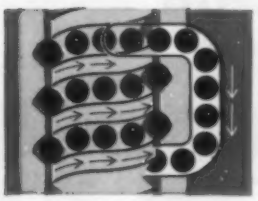
Let's start at the beginning, with the familiar principle that there's far less friction in *rolling* than in *sliding*. By applying this principle,



the *Safety ball/bearing Screw* radically increases the efficiency of rotary-to-linear motion (and vice versa). Instead of *sliding*, mating surfaces *glide* on rolling steel balls.

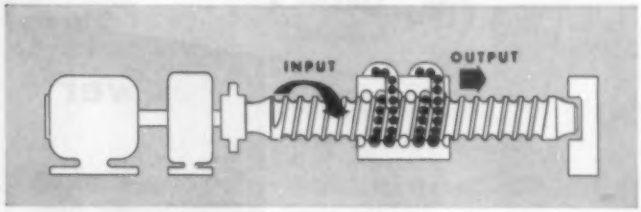


Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.



At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate while screw operates.

ADVANTAGES FOR MACHINE DESIGNERS



Compared with the conventional Acme screw's efficiency of less than 25%, that of the *Safety b/b Screw* ranges from 90% to 95%! This makes it by far the most efficient known mechanism for translating rotary-to-linear motion, or vice versa. Combined with an electrical, hydraulic or pneumatic power source, the *Safety b/b Screw* forms an actuator with tremendous advantages for the machine designer. For example, it can enable you to:

SAVE POWER—by requiring only 1/3 as much torque as the conventional Acme screw for the same amount of lineal output, and with far lower static break-away, the *Safety b/b Screw* requires much less starting and driving power. This permits the use of much smaller motors with less load on the electrical system.

ASSURE PRECISION POSITIONING—unlike some other types of actuators, the *Safety b/b Screw* permits absolute accuracy within thousandths of an inch, plus perfect synchronization of two or more movements. Where necessary, backlash can be completely eliminated by pre-loading, with only about 2% loss of efficiency.

REDUCE INSTALLATION AND OPERATING COSTS—the *Safety b/b Screw* permits significant savings in the form of smaller motors, less auxiliary equipment and less power consumption. It also assures less maintenance and longer life because its "Gothic arch"-shaped races greatly decrease dirt sensitivity, and wear due to friction is negligible.

ANY SIZE FROM 1½ IN. TO 39½ FT. IN LENGTH

Every *Safety b/b Screw* is individually engineered for its particular application. Our engineers are eager to help solve your actuator problems *now*.

MAIL COUPON TODAY FOR YOUR ENGINEERING DATA BOOK

(or see our section in Sweet's Product Design File)

Saginaw Steering Gear Div.,
General Motors Corp.
Dept. 3J, Saginaw, Michigan
Please send your Engineering Data Book to:

Name—Title_____

Firm_____

Address_____

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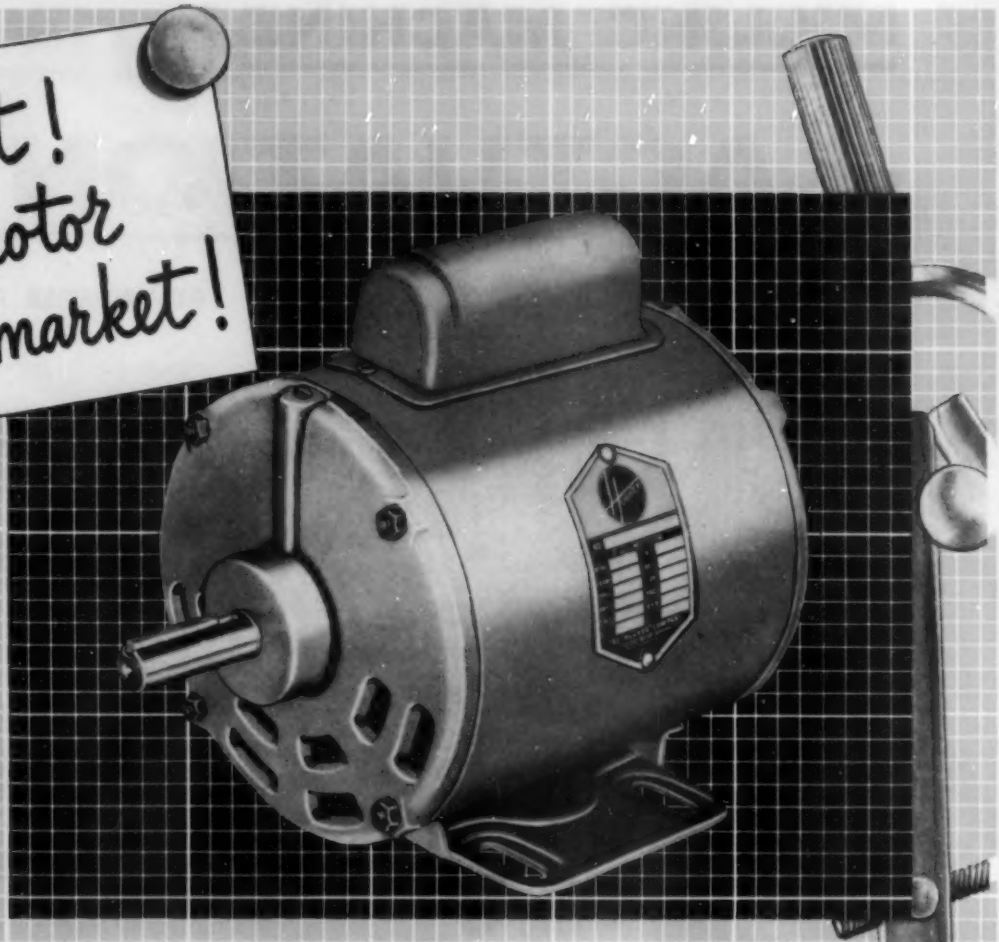
Safety ball bearing Screw by Saginaw

This is it!
Newest motor
on the market!



We invite you to test-run

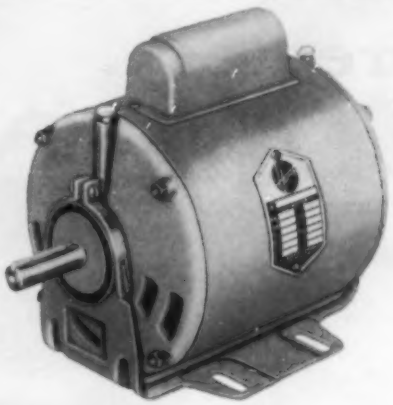
HOOVER

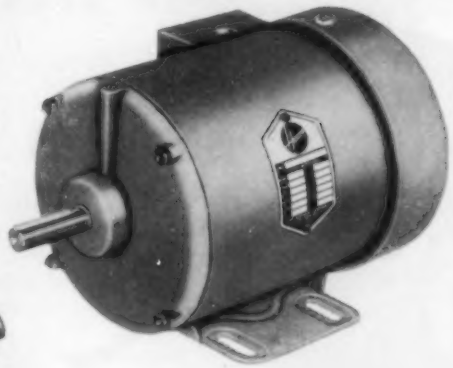
A completely new FRACTIONAL HORSEPOWER

If you make equipment powered by a fractional horsepower motor, we know you'll find the new Hoover Hy-Drive is the compact efficient power source you've been looking for. That's why we invite you to test-run this completely new motor —see for yourself the improved performance you can count on from this tough, dependable power package.

Hoover can add special mechanical or electrical details to order, make changes at any stage of production on short notice. Hoover engineers will be glad to work with your engineers to find the most economical answer to your performance requirements.

- Compact—more power per pound
- Higher overload capacities
- Newest "Mylar"* insulation in stator slots
- New trouble-free centrifugal starting switch (proven through 6 million cycles—ten times normal life—under all types of operating conditions)
- Improved ventilating design—permits complete air flow over windings, for maximum motor cooling





- Rugged 11-gauge heavy steel frame—provides rigidity and alignment equal to heaviest in industry
- Exclusive ribbed base—resists bending, provides widest contact points for maximum rigidity
- Conforms to NEMA standards for "56" Frame motors
- Available from ¼ H.P. to 1 H.P.
- Split-phase, capacitor start, or polyphase
- Dripproof or totally enclosed
- Ball or sleeve bearing
- Rigid, resilient or face mount
- Suitable for vertical or horizontal installation

*Du Pont polyester film.

HY-DRIVE

motor..detailed to order

And when you power with Hoover motors, service for your customers is seldom more than a day away—anywhere in the world. Over 300 Hoover Agencies are ready to give immediate expert attention. Send coupon for full details, today.

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I would like to test-run the new Hoover HY-DRIVE.
Please send me full details. I am particularly interested in motors for _____
(Indicate type of equipment)

Name _____

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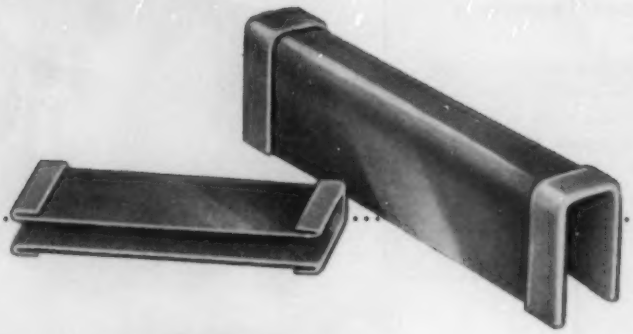
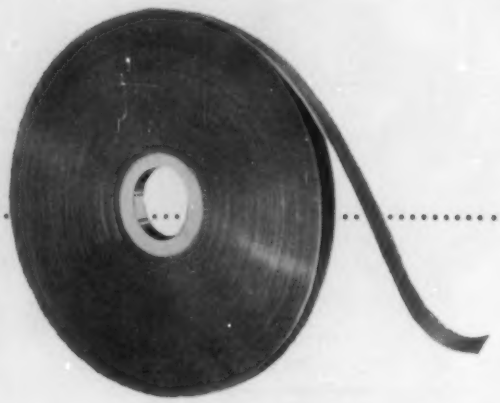
Dobeckmun creates...

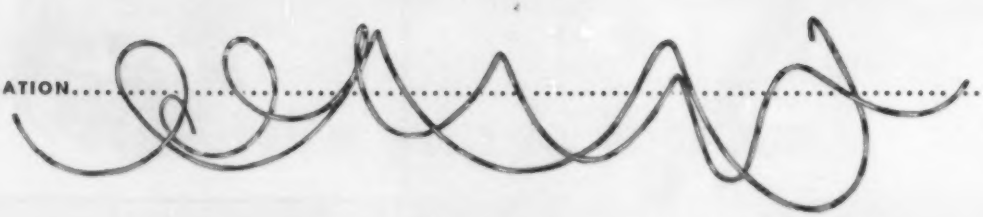
DOBAR® SLOT INSULATION



LEXEL® TAPES



MYLAR* INSULATION



materials for all sorts of industrial uses, large and small!

Dobeckmun has solved thousands of industrial problems of every size and degree of complexity—and some of our biggest achievements have occupied the smallest space. Electrical insulation, for example. Dobeckmun works with flexible materials including acetate, paper and Mylar to pack amazing dielectric strength into amazingly little space. Dobeckmun specializes in the laminating, slitting, plastic coating and printing of flexible materials. Let us know what YOUR needs are. If what you need hasn't been done, Dobeckmun will do it.

*trademark DuPont

Dobeckmun Company, Cleveland 1, Ohio · Berkeley 10, California

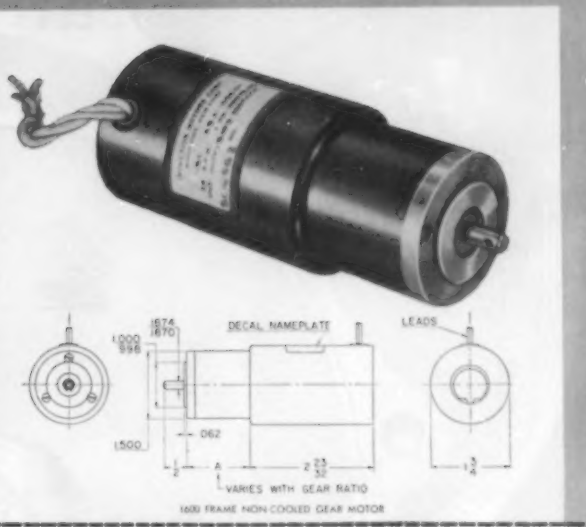
Laminating . . . Plastic coating . . . Slitting . . . Printing of flexible papers, foils, films and cloth

Write today for complete catalog and samples to P. O. Box 6417, Cleveland

These *New* GEAR HEADS are our Answer to HIGH TORQUE at LOW SPEEDS

We are producing a complete line of gears for our 1600 frame motors to meet any precision, low speed high torque requirements. Gear reduction units built to withstand impact, vibration and high acceleration are available. If your requirements are such that control problems are the important factor we incorporate the correct actuating device in the design.

Our 1600 frame motors are available in highly efficient induction, non-synchronous types or in hysteresis or reluctance synchronous types. They may be for 60 cycle, 400 cycle or variable frequency operation (50-1600 cps), single or polyphase. Supplied in ratings from 1/1000 to 1/10 horsepower for continuous duty. Housing is anodized aluminum. Ball or sleeve bearing construction. Will withstand ambient temperatures from —55° up to 150°C.



1600 FRAME NON-COOLED GEAR MOTOR

1600 FRAME SELF-COOLED GEAR MOTOR

TYPICAL APPLICATIONS

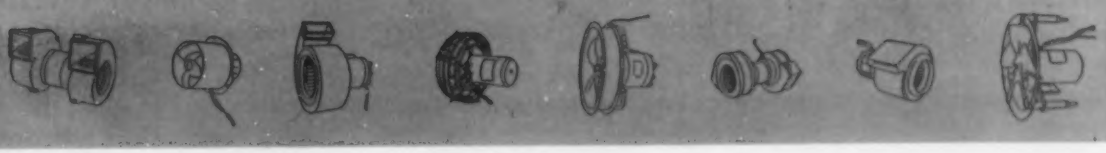
Servo Mechanisms • Fire Control Systems
Automatic Flight Controls • Sine Wave Alternators
Aircraft Cameras

If you have any problem involving sub-fractional horsepower motors, Induction Motor Corporation is your logical source of supply. We manufacture induction, synchronous and servo motors for gearhead, blower, fan and torque motor applications. We can either build them to your specifications or design them to meet your requirements.

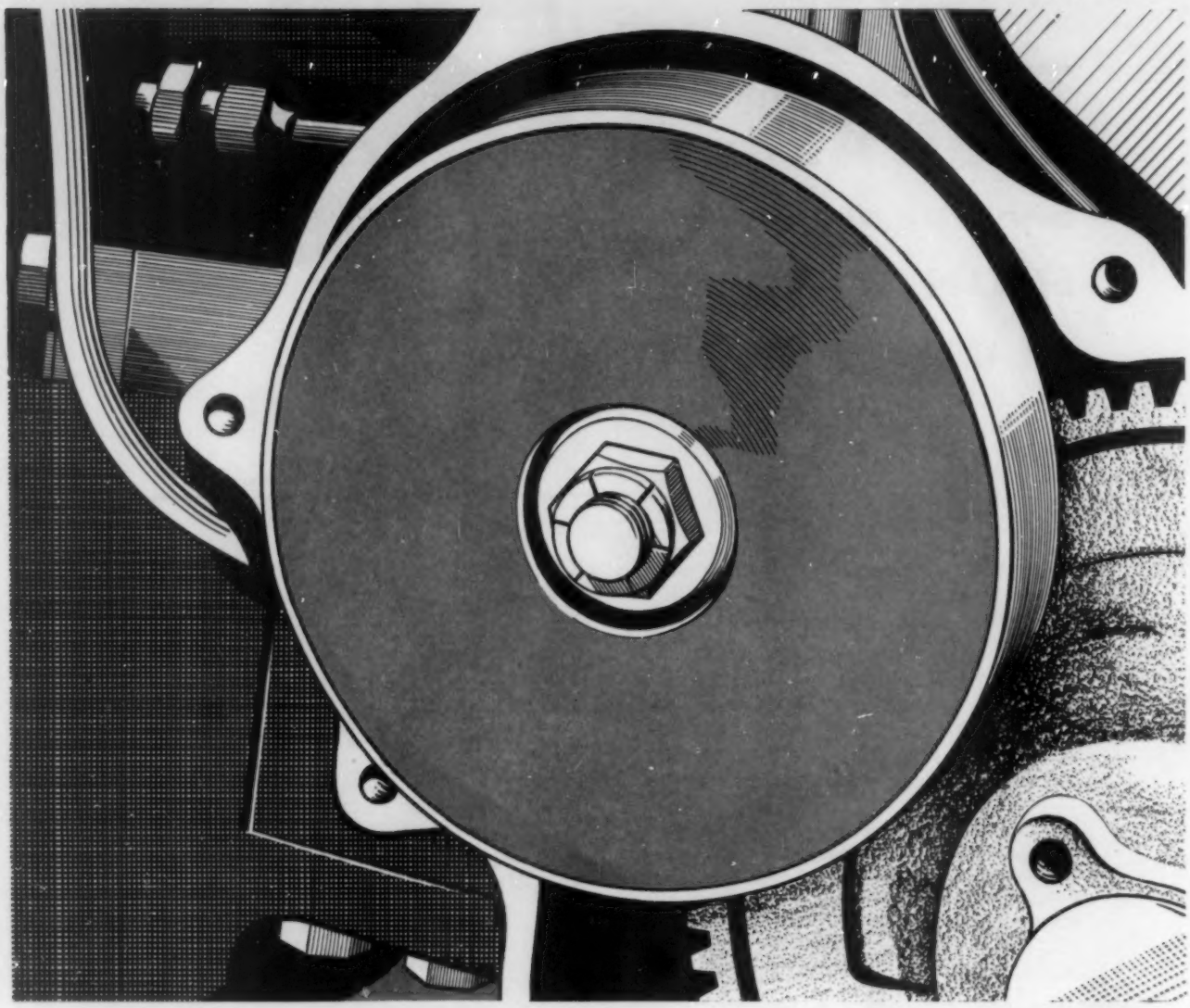
For the answer to your problems, write or phone:

Induction Motors Corp.

570 Main St., Westbury, L. I., N.Y. • Phone WEstbury 7-7070



FLEXLOC AT WORK



MORE AND MORE FLEXLOC LOCKNUTS are being used where assemblies must be held together. This electric chain saw is a good example of an application for which FLEXLOCS are well suited.

A FLEXLOC Self-Locking Nut is used here to hold the driver gear in place. Even high-speed cutting, extreme vibration, and rough handling do not loosen the FLEXLOC locknut. These one-piece, all-metal locknuts are available in a full range of sizes. Standard FLEXLOCS are stocked by authorized industrial distributors in sizes from #4 to 2". Write for Bulletin 866 and samples. STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

DO YOU KNOW? Standard FLEXLOCS smooth off rough bolt threads. The locking threads on all-metal FLEXLOCS are not chewed up when used on rough bolts.

Standard FLEXLOCS lock securely on bolts varying in diameter tolerances. The all-metal, resilient locking sections of the nut accommodate themselves to the diameter tolerances.

Standard FLEXLOCS are one piece, all metal. They are not affected by temperatures to 550°F. Nuts lacking these features have a more restricted temperature range.

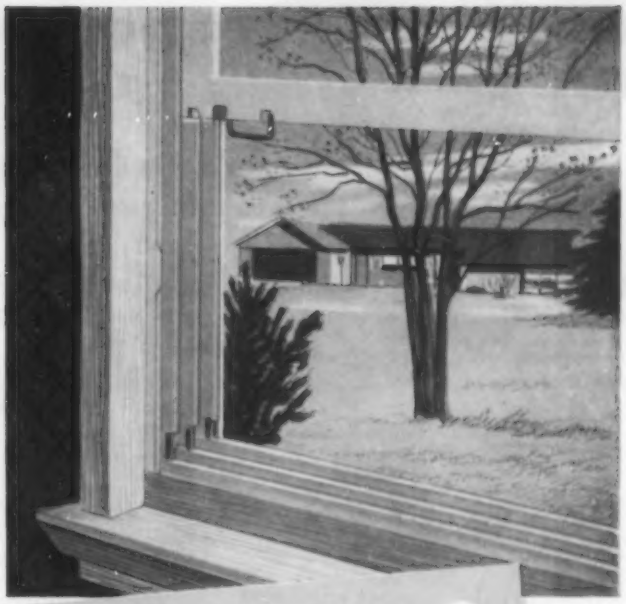
Standard FLEXLOCS lock securely—stopped or seated—when 1½ threads of a standard bolt are past the top of the nut.

Standard FLEXLOCS are not affected by moisture, oil, dirt or grit. They lock efficiently under all conditions, regardless of the vibration encountered.

FLEXLOC®
LOCKNUT DIVISION
SPS
JENKINTOWN PENNSYLVANIA

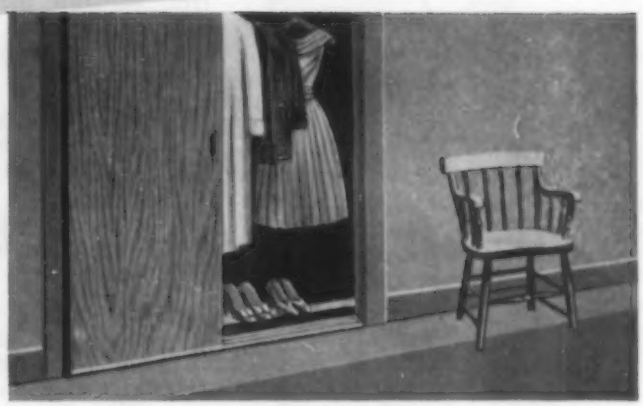
Here's Kralastic in window channels...

- practically friction-free
- non-warping
- non-swelling
- resistant to weather
- extremely tough
- corrosion-proof
- highly insulative
- unbothered by normal temperature change
- unusually abrasion resistant



WHY NOT KRALASTIC...?

...refrigerator roll-out shelf channels



...door slides

Door slides and refrigerator slide rails of Kralastic would never stick or bind once properly installed. There'd be no rust or corrosion, never any need for painting, no warping out of shape. Doors would run smoothly, easily, quietly, *indefinitely.*

What's more, these Kralastic runners would be easy to install—readily sawed to length, drilled, nailed or screwed in place. Color would be permanent, too, *built in* so it couldn't flake, peel, or wear off.

And with Kralastic's great dimensional stability and self-lubrication properties, it allows a permanently snug fit to end banging or rattling from vibration.

Tough, versatile Kralastic rubber-resin recommends itself not only to these applications, but to hundreds more. With a combination of advantages no other material can match, it's already proved itself in pipe for brine, natural gas, and many chemicals—in lawn mower wheels, safety helmets, a host of really tough applications.

See what Kralastic rubber-resin can do for *you.* Write us today

Extruded Kralastic window channeling produced by Robert S. Crane Associates, Columbus, Ohio.

Naugatuck Chemical

Division of United States Rubber Company
Naugatuck, Connecticut

US RUBBER

BRANCHES: Akron • Boston • Charlotte • Chicago • Los Angeles • Memphis • New York • Philadelphia • IN CANADA: Naugatuck Chemicals, Elmira, Ontario
Rubber Chemicals • Synthetic Rubber • Plastics • Agricultural Chemicals • Reclaimed Rubber • Latices • Cable Address Rubexport, N.Y.

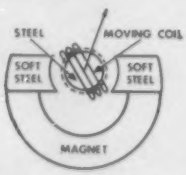
(*Advertisement*)

Carboloy Trends and Developments for Design Engineers...

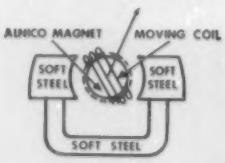
How to select the right permanent magnet
How to improve products by vacuum melting

Simplified permanent magnet makes meter more efficient

There was nothing *wrong* with this meter assembly:



But Carboloy magnet engineers brought a large meter manufacturer substantial savings by helping to design a *better* one:



This new meter assembly uses a Carboloy® Alnico 5 permanent magnet, only one quarter the volume of the previous steel magnet. Yet it provides the same air-gap field intensity – preserving the meter sensitivity.

Today, more and more designers call upon Carboloy magnet engineers to solve the complex problems involved in selecting the proper magnets for their products.

That's because Carboloy magnet engineers are experts in weighing the *technical* variables of:

required field strength
magnetic-material characteristics
magnet size and configuration

against the *economic* variables of:

cost per pound
energy output per dollar
availability and delivery

to attain optimum performance at minimum cost.

Carboloy assistance to designers is not limited to selection and design of magnets. Carboloy engineers can also help solve many of the problems associated with the use of permanent magnets: magnetizing, demagnetizing, testing, and stabilizing. Why not write, today, for more information.

Vacuum melting produces new engineering materials

Melting metals and alloys in a vacuum – instead of in air –eliminates undesirable impurities, dissolved gases, and inclusions. But even more important to the designer, this "cleansing" operation brings spectacular improvements in physical properties and fabrication characteristics.

These improvements add up to increased performance and longer life.

Through closer composition control, vacuum melting not only improves existing metals and alloys, but makes possible entirely new alloys with:

Greater ductility. Tensile ductility in some of our high-temperature jet bucket alloys has been improved, by a ratio of 3 to 1, by vacuum processing. Forging and forming to tricky configurations is easier.

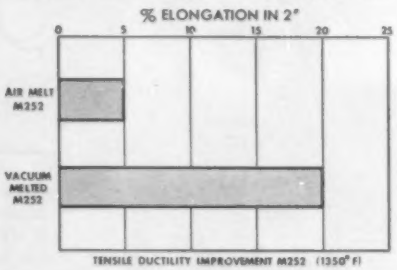
Greater impact strength. Chromium steels, such as 430 and 446, can be made with a much lower transition temperature (—50°C vs. 100°C). Room-temperature impact values for these vacuum-melted steels are 20 to 30 times higher.

Improved stress-rupture strength. On some high-temperature alloys, vacuum melting increased stress-rupture strength 15% to 20%.

Increased fatigue strength. Bearings made of vacuum-melted 52100 steel have up to four times the service life. In rotating beam fatigue tests, vacuum-melted 52100 has run up to 10^7 cycles before failure; air-melted 52100 ran 10^4 cycles.

Improved corrosion resistance. Exposed surface impurities in air-melted materials act as small galvanic cells, accelerating corrosion. Vacuum-melted alloys have a minimum of inclusions, and therefore greatly reduce corrosion-causing surface impurities.

Improved electrical properties. Through greater cleanliness and purity, vacuum processing improves both electrical conductivity and magnetic properties.



Vacuum-melted metals yield more pieces per pound, and any rejects have greater salvage value.

Experienced Carboloy engineers are now ready to help you utilize the tremendous potential of vacuum melting . . . through the improvement of existing metals and alloys, or the development of new alloys.

And Carboloy engineers can also assist you with improving your products through the use of other Carboloy Created-Metals: *Cemented carbides* for combatting wear; *Hevimet* for high-density and radioactive shielding applications; *Thermistors* for detection, measurement, and control of minute temperature changes.

For more information on the design possibilities of Carboloy Created-Metals, write today, outlining your application.

"Carboloy" is the trademark for products of the Carboloy Department of General Electric Company

CARBOLOY
DEPARTMENT OF GENERAL ELECTRIC COMPANY
11127 E. 8 Mile Street, Detroit 32, Michigan

CARBOLOY CREATED-METALS FOR INDUSTRIAL PROGRESS

*consistent quality

is as important in the pin as in the gear

To function effectively, a spring pin must drive easily into holes drilled to normal production tolerances, compressing as driven. To drive easily, hold firmly and fit flush, the pin —*every* pin—must meet the strict requirements of specifications such as those prepared by the SAE and the Military Services.

Since failure of a pin can be as costly as a failure of any other precision part, it is important to check the pins *you* buy for uniformity . . . uniformity of diameter and length, shear strength, hardness, insertion and removal forces, and recovery of diameter.

Rollpin has been tested many times—by many manufacturers—with a consistently high performance record. It has been widely recognized as the "quality" fastener of its type. In this case, quality can be—and should be—measured. We strongly urge that you test for quality when buying spring pins.

ELASTIC STOP NUT CORPORATION OF AMERICA

Dept. R28-42, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey

Please send the following free fastening information:

☐ Rollpin samples
☐ Rollpin bulletin
☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Firm_____

Street_____

City_____ Zone____ State_____

FOR BETTER DESIGNING WITH THERMOPLASTICS

GROUPS OF BAKELITE STYRENE-BASED TRADE-MARK MATERIALS

Five groups of styrene-based plastics—from a single supplier—help to meet your specific product requirements with respect to production, performance, and cost.

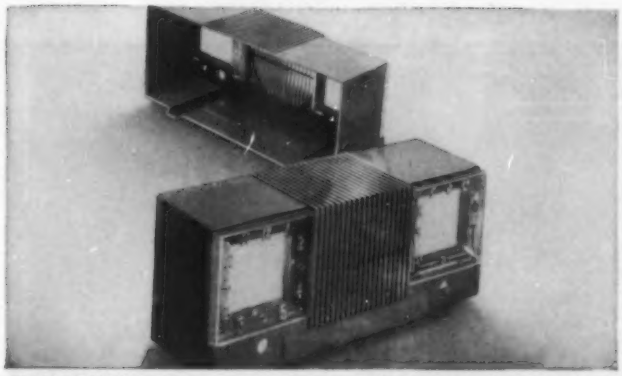
For many jobs, these materials are selected for the fine appearance and performance advantages which they impart to scores of new products—fine detail, glossy surface, color, resistance to chemicals and to impact . . .

Other jobs take advantage of production benefits—for example, a 50 per cent reduction in molding time with SMD-3500.

With five of these materials to choose from, you can expect a range of properties that will closely fit your needs. You can depend on these materials because rigid quality control governs every step in their production. They are backed by Bakelite Company's 45 years of experience in the plastics industry, available to you through the services of qualified representatives. Consult your plastics molder, or write Dept CE-10.

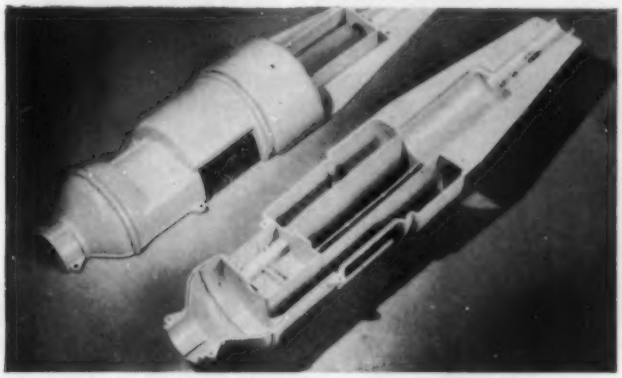
IMPACT STYRENES • EXTRA-HIGH IMPACT STYRENES • ACRYLONITRILE-STYRENE COPOLYMERS

GENERAL-PURPOSE STYRENES • HIGHER HEAT-RESISTANT STYRENES



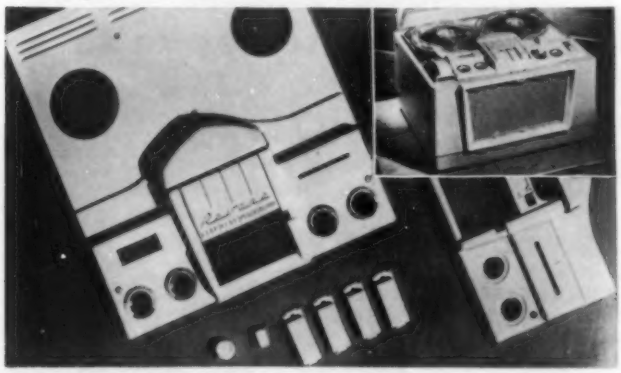
SMD-3000—the BAKELITE Styrene Plastic with the high heat distortion point of 197 deg. F. measured on an unannealed test bar ¼ in. thick. Has same color and clarity as other BAKELITE Styrene molding materials. Warping and distortion were completely eliminated in molding these radio cabinets from SMD-3000. They showed no stress-crazing even after immersion in n-heptane. Notice fine details, glossy surfaces in these front and rear views.

SMD-3500—BAKELITE General-Purpose Styrene. Noted for its speed in production. One manufacturer reported a 50 per cent decrease in molding cycle time plus complete elimination of sink marks. Another was able to reduce molding temperature by 50 deg. F. while gaining a faster cycle. SMD-3500 is equally serviceable for large moldings like this refrigerator crisper drawer and for the small, close-fitting syringe holder parts shown here.



TMD-5151—BAKELITE High-Impact Styrene. Has over eight times the impact strength of general purpose styrenes. (ASTM average Izod test values using notched ¼ in. bar at 74 deg. F.). Inherently high plasticity results in fastest set-up speed available with a high-impact styrene—an important production advantage. Surface gloss is outstanding. Opaque color range is unlimited. Colors can be duplicated from blend to blend. These toy vacuum cleaner parts show intricate details possible with TMD-5151.

TMD-2155—BAKELITE Extra-High Impact Styrene. Has an impact strength about eighteen times that of general-purpose styrenes. (ASTM average Izod test values using notched ¼ in. bar at 74 deg. F.). Stays tough down to −13 deg. F. Has high heat distortion point, superior surface gloss, and excellent color. Economy, color, and strength are features of this lawn mower wheel molded from TMD-2155.



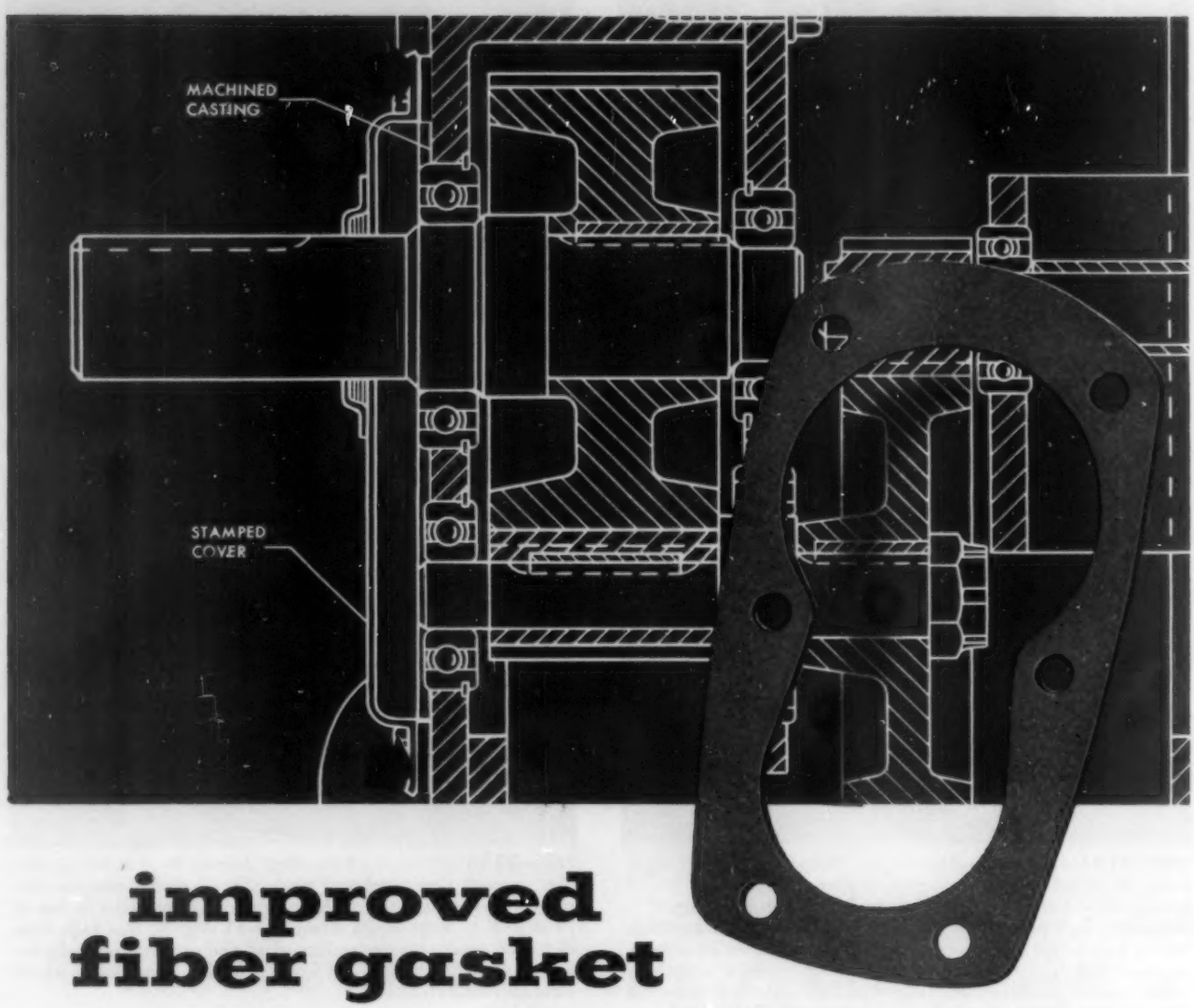
C-11 Plastic—An Acrylonitrile-Styrene copolymer that combines toughness with rigidity, color and gloss. Its chemical resistance fits C-11 for kitchen wares, food packaging, refrigerator parts. It withstands food acids and oils, gasoline, moth balls, soaps, detergents, carbon tetrachloride. Will not crack or craze when exposed to substances harmful to surface of many plastics. C-11 was selected for parts of the tape recorder illustrated to provide lasting, fine appearance despite exposure to constant wear and tear.

BAKELITE
BRAND
STYRENE PLASTICS

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario

The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC



improved fiber gasket

stops bolt torque loss, ends cover plate leakage

Customers were complaining that frequent tightening of bolts was necessary to prevent oil leaks at the cover plate of a motor speed reducer. The manufacturer learned that the molded seal between the cover plate and gear housing flowed under pressure and permitted oil to leak. The situation was especially serious since many of the speed reducers were used in food processing equipment where even slight oil leaks could not be tolerated.

By changing from a cast metal to a stamped face plate and using a fiber gasket, the manufacturer hoped to reduce torque loss. But when he tested several conventional fiber materials in the new joint, each one in time lost its saturant, shrank, and leaked.

An efficient seal was found, however, when Armstrong CS-301 Accopac® fiber sheet was used. This low-cost gasket material retained its non-extractable latex binder . . . it did not shrink or leak. And its excellent kickback maintained bolt torque.

The dependability of Armstrong Accopac helped this manufacturer find an economical solution to a serious problem. Possibly it can do the same for you.

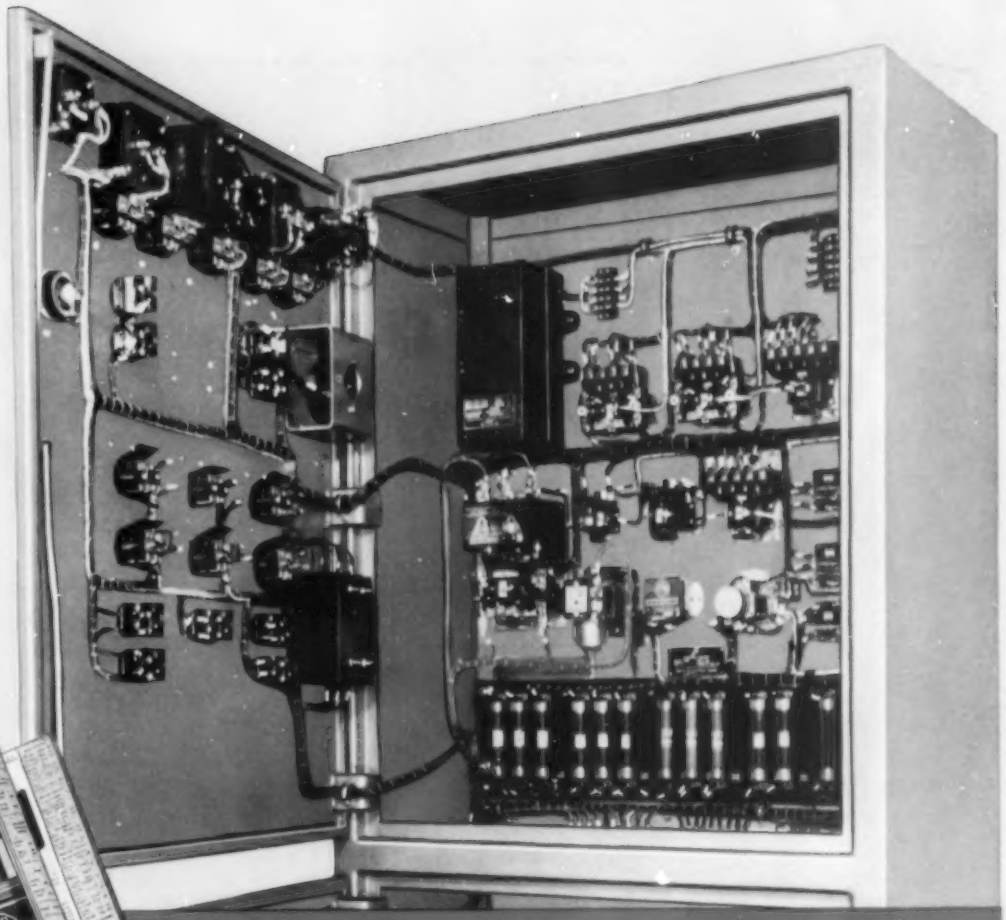
FREE 24-PAGE MANUAL—For data on Accopac and facts on Armstrong synthetic rubber, cork composition, and cork-and-rubber, look for "Armstrong Gasket Materials" in Sweet's product design file. For your own copy, write Armstrong Cork Company, Industrial Div., 7004 Irvin St., Lancaster, Pa. **When you order from your local gasket fabricator, be sure to specify Armstrong Gasket Materials.**

Armstrong Accopac

. . . used wherever performance counts

The Sign of
QUALITY
MOTOR CONTROL

Control panel for BETA dust precipitator rectifier, shown below with door closed. It has 3 Bulletin 709 starters, 2 Bulletin 700 relays, Bulletin 702 contactor, and Bulletin 809 overload relay. On door are 20 Bulletin 800T oiltight push buttons and pilot lights.



MANUAL and AUTOMATIC COMPONENTS for *Trouble Free* Control Panels

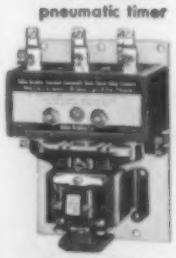
Automatic control panels must be reliable . . . not just MOST OF THE TIME but ALL OF THE TIME. The failure of only one component . . . JUST ONCE . . . may be costly in spoilage and production delay.

A-B controls continue in first place in dependable switching because they are so simple. They have no troublemaking pivots, pins, or bearings to gum up and stick. Their double break, silver alloy contacts never require maintenance until all contact material has been worn away.

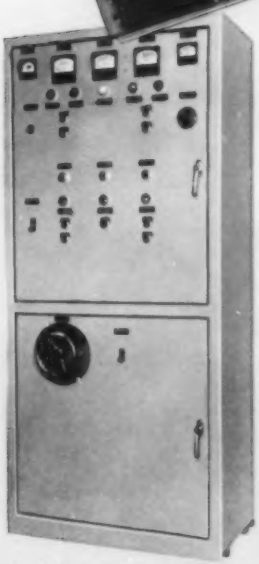
Specify Allen-Bradley controls for your machines. Send for the A-B Handy Catalog.

Allen-Bradley Co., 1316 S. Second St.
Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd.
Galt, Ont.

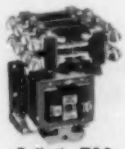
Bulletin 849
pneumatic timer



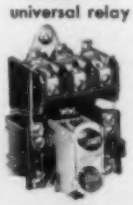
Bulletin 702
Size 2 contactor



BETA dust precipitator control cabinet with A-B oiltight push buttons



Bulletin 700
universal relay

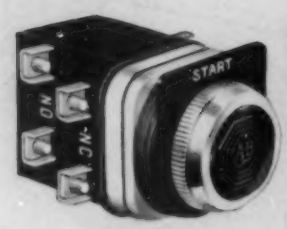


Bulletin 609
manual starter

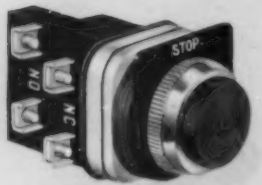
Bulletin 709
solenoid starter

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

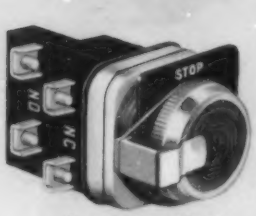
5-55-R



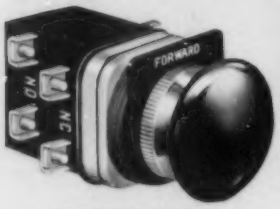
Start button



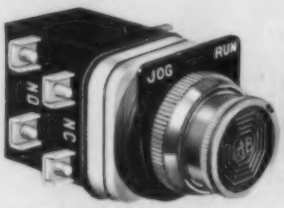
Stop button



Stop button with locking attachment

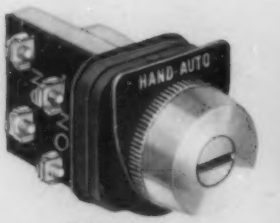


Mushroom head button



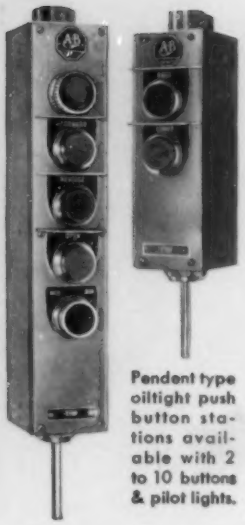
Jog button

Selector switch



Coin slot selector

Open view of 2-button oiltight master station showing method of mounting

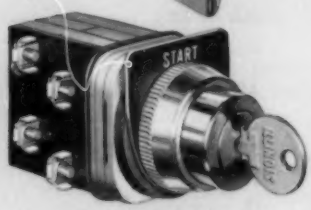


Pendent type oiltight push button stations available with 2 to 10 buttons & pilot lights.

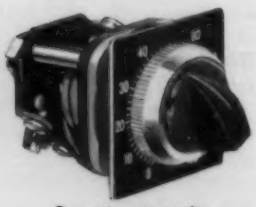
ALLEN-BRADLEY OILTIGHT PUSH BUTTON LINE

that *Satisfies Every Requirement*

Jog button with Start button and Stop & Jog lever



Cylinder lock button



Potentiometer unit

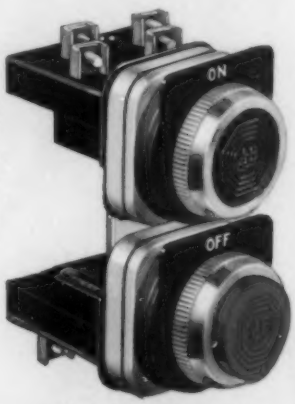
Pilot light Transformer type

Here are a few Allen-Bradley oiltight push button units for machine tools that can be used in endless combinations. All have a flexible, oiltight diaphragm between button and contact block to exclude oil or cutting fluids from contacts. The silver contacts are maintenance free.

Contact blocks may be assembled interchangeably with any type of button. They are available with 1 NO-NC; 2 NO-NC; 4 NO-NC; 2 NO; or 2 NC contacts. Pilot lights of matching design are standard items. See the A-B Handy Catalog for details.

Allen-Bradley Co., 1316 S. Second St.
Milwaukee 4, Wis.

In Canada—
Allen-Bradley Canada Ltd.
Galt, Ont.



Two-button maintained contact button

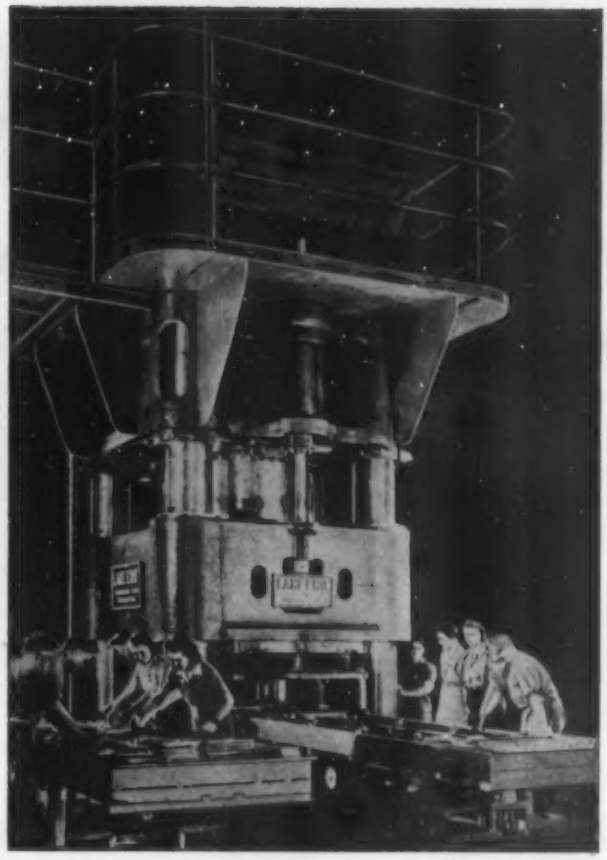
5-55-RM

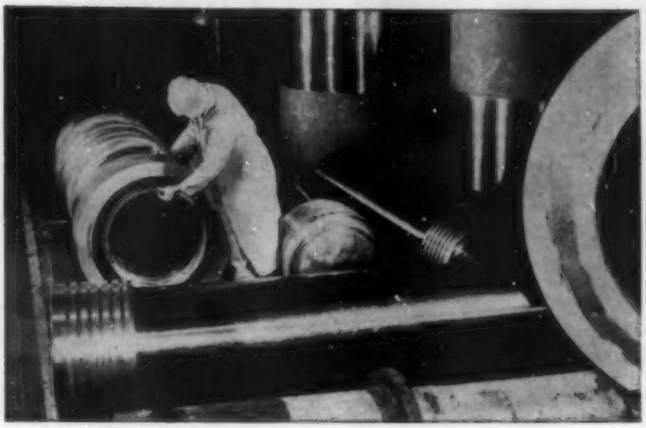
A-B Quality

ALLEN-BRADLEY QUALITY

BULLETIN 800T PUSH BUTTONS

The production capacity of this 5,000 ton forming press, installed in an aircraft plant, is so great it requires 25 persons to load and unload the four tables. To provide dense, sound and uniform structure in hydraulic press rams, Lake Erie specifies the component in nickel cast iron.





Lake Erie's Engineers specify rams of

NICKEL CAST IRON for strength... toughness... tightness

YOU'LL FIND MAXIMUM PRESSURE TIGHTNESS, together with extra toughness and strength, in rams for Lake Erie's powerful hydraulic presses.

Cast iron containing up to 1½ percent nickel provides this combination of properties in all Lake Erie rams.

Suitable additions of nickel to properly adjusted base mixtures provide castings with uniform, fine-grained structures.

In addition, nickel in gray iron minimizes chill and consequently the formation of free iron carbides. This results in strong yet readily machinable castings, without sacrifice of hardness or wear-resistance.

Lake Erie presses also utilize alloys containing nickel for dies as well as many other components.

For instance, on extrusion presses, the containers and container liners are nickel alloy steel forgings. And on many column and side housing types of hydraulic presses you'll find the repeated load of press operation absorbed by platen inserts or wear plates of nickel-chromium steel.

In many applications, alloys containing nickel give optimum performance and prove lowest in ultimate cost. So, whenever you have a metal problem, send us the details. We'll be glad to help you with suggestions based on wide practical experience.

The International Nickel Company, Inc.
67 Wall St., New York 5, N. Y.

INCO TRADE MARK

Please send me booklet entitled, "Guide to the Selection of Engineering Irons."

Name_____ Title_____

Company_____

Address_____

City_____ State_____

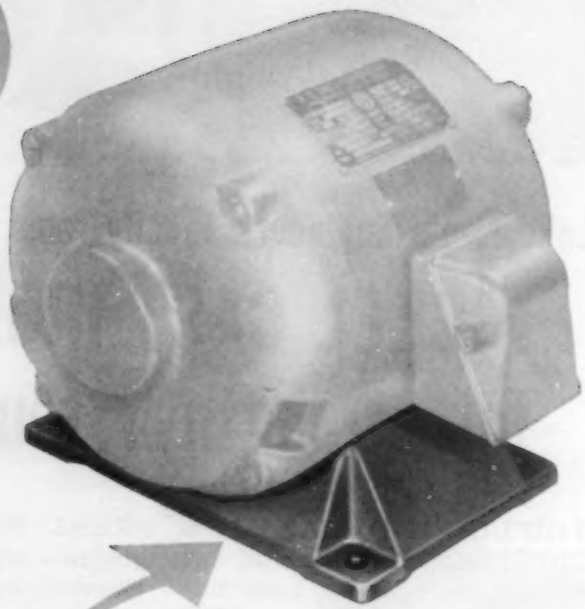
THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Optional frame mountings

mean you needn't change product design to enjoy all the advantages of the new NEMA ratings

1. Want to use new NEMA mounting dimensions for integral horsepower motors?

Do it with A. O. Smith Integrals! Optional frame mountings fit NEMA sizes 182, 184, 213, 215.



2. Want to keep your old mountings but still enjoy all the advantages of new NEMA ratings?

Do it with A. O. Smith integrals! Optional frame mountings fit old NEMA sizes 203, 204, 224, 225.

A. O. Smith understands your problems . . . understands the costs involved in adapting your manufacturing processes to suit the motor industry's new mounting dimensions for integral hp motors.

That's why we offer our motors with optional frame mountings — drilled to the old specifications or the new. You get all the performance — all the advantages — you'd want from an integral hp motor (1 — 150 hp) . . . plus easy adaptability.

Another reason why it pays to see A. O. Smith first for motors. Our specialty is custom-engineering to fit your particular needs. Write today for full details.

Through research A.O. Smith *. . . a better way*

A.O.Smith

CORPORATION

ELECTRIC MOTOR DIVISION

P. O. Box 170 • Dayton, Ohio

International Division: Milwaukee 1, Wisconsin

ALSIMAG®

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AlSiMag offers top-notch technical ceramics of every type . . . Die Pressed, Extruded, Machined. Simple or intricate shapes. Large designs. Miniatures. Metal Ceramic Combinations.

Complete equipment for efficient production in any quantity. Widest selection of materials. Competent Engineering and Redesign Service. Tooling at lowest cost from the AlSiMag Die Shop. Plenty of kiln space. Quality Control. Thoroughly trained personnel. Continuous Research.

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AMERICAN LAVA CORPORATION

A SUBSIDIARY OF MINNESOTA MINING AND MANUFACTURING COMPANY

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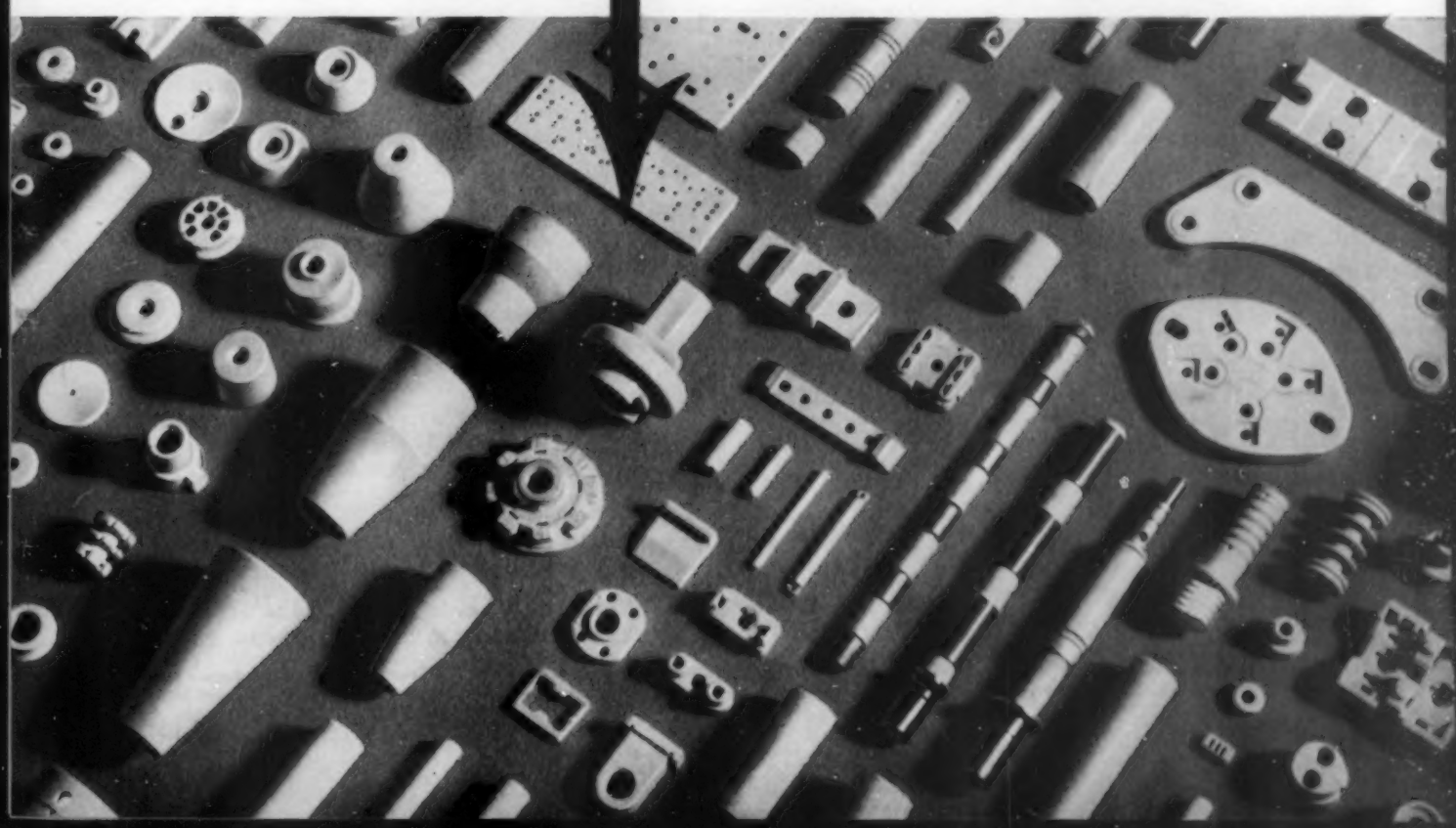
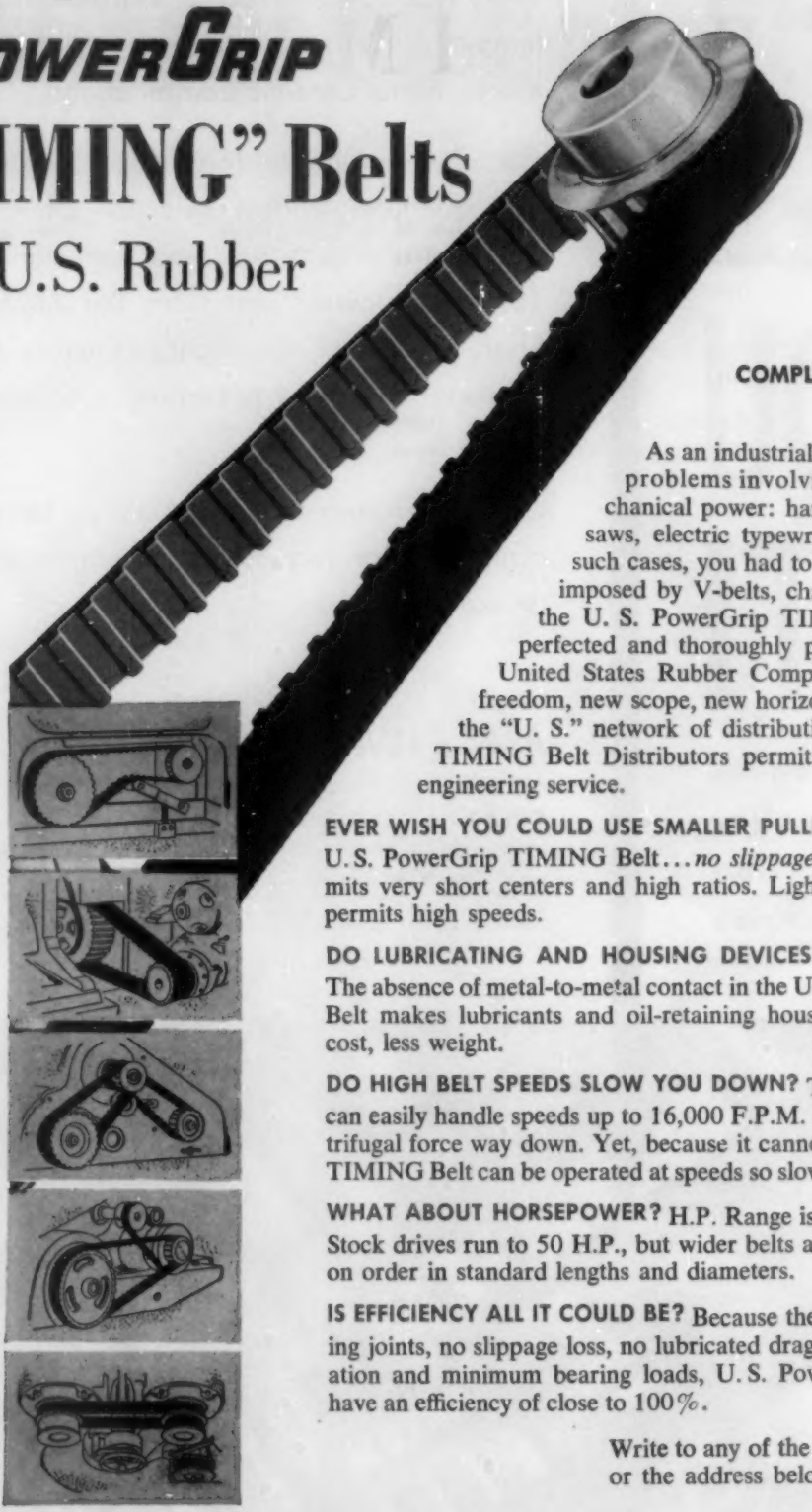
BRANCH OFFICES IN THESE CITIES (SEE YOUR LOCAL TELEPHONE DIRECTORY): Cambridge, Mass. • Chicago, Ill. • Cleveland, Ohio • Dallas-Houston, Texas Indianapolis, Ind. • Los Angeles, Calif. • Newark, N. J. • Philadelphia-Pittsburgh, Pa. St. Louis, Mo. • South San Francisco, Calif. • Syracuse, N. Y. • Tulsa, Okla. **Canada:** Irvington Varnish & Insulator Division, Minnesota Mining & Manufacturing of Canada, Ltd., 1390 Burlington Street East, Hamilton, Ontario, Phone Liberty 4-5735.



A complete line of PowerGrip "TIMING" Belts by U.S. Rubber



U.S. PowerGrip TIMING Belt with its positive engagement takes hold of the pulley grooves with perfect fit, perfect grip. Slippage or power loss can't happen.

FAST DELIVERY
COMPLETE ENGINEERING SERVICE
FULL STOCKS

As an industrial designer, you have often met problems involving the transmission of mechanical power: hand tools, lathes, drill presses, saws, electric typewriters are some examples. In such cases, you had to go along with the limitations imposed by V-belts, chain drives or gears. But now the U. S. PowerGrip TIMING® Belt, developed and perfected and thoroughly proved for over six years by United States Rubber Company, gives you entirely new freedom, new scope, new horizons of design. MOREOVER, the "U. S." network of distribution centers, sales offices and TIMING Belt Distributors permits fast supply plus complete engineering service.

EVER WISH YOU COULD USE SMALLER PULLEYS? You can with the U.S. PowerGrip TIMING Belt... *no slippage, no take-up.* This permits very short centers and high ratios. Light weight of PowerGrip permits high speeds.

DO LUBRICATING AND HOUSING DEVICES GET IN YOUR WAY? The absence of metal-to-metal contact in the U.S. PowerGrip TIMING Belt makes lubricants and oil-retaining housings unnecessary. Less cost, less weight.

DO HIGH BELT SPEEDS SLOW YOU DOWN? The U.S. TIMING Belt can easily handle speeds up to 16,000 F.P.M. Light weight keeps centrifugal force way down. Yet, because it cannot slip, U. S. PowerGrip TIMING Belt can be operated at speeds so slow as to be imperceptible.

WHAT ABOUT HORSEPOWER? H.P. Range is 1/100 to 300 or more. Stock drives run to 50 H.P., but wider belts and pulleys can be made on order in standard lengths and diameters.

IS EFFICIENCY ALL IT COULD BE? Because there are no friction-creating joints, no slippage loss, no lubricated drag—minimum heat generation and minimum bearing loads, U. S. PowerGrip TIMING Belts have an efficiency of close to 100%.

Write to any of the 27 District Sales Offices or the address below. Ask for free catalog.

"U. S." Research perfects it..."U.S." Production builds it... U. S. Industry depends on it

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MECHANICAL GOODS DIVISION · ROCKEFELLER CENTER, NEW YORK 20, N. Y.

Hose • Belting • Expansion Joints • Rubber-to-metal Products • Oil Field Specialties • Plastic Pipe and Fittings • Grinding Wheels • Packings • Tapes
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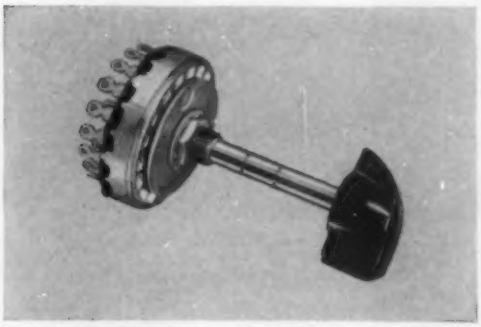
The switch your product needs may be a Standard Mallory Model

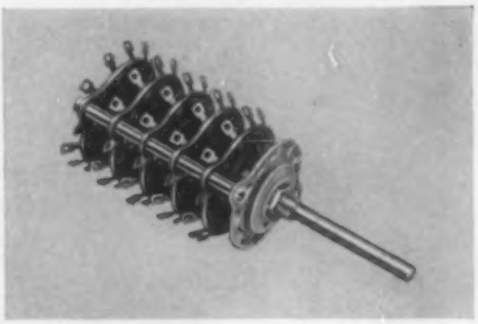
Before designing a custom switch for your product, take a look at the varied line of standard Mallory switches. Mallory offers you an unequalled selection of switches . . . rotary, slide, push button, jack and time sequence control types . . . both manually and motor operated.

Some of the more than *twenty basic types* of switches are pictured here. These types are used for any and all switching applications involving up to 20 amperes . . . for such uses as electric appliances, communication instruments, test equipment and the like—both civilian and military.

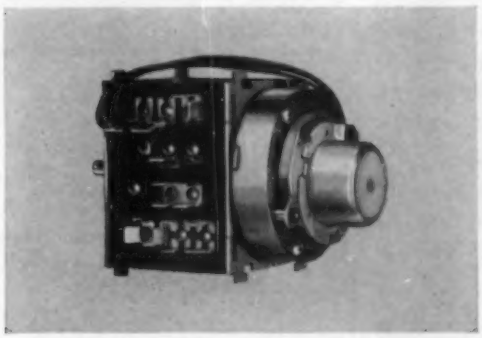
Mallory switch-design engineering assistance is yours for the asking . . . perhaps we can save you time and money with your switching problems.



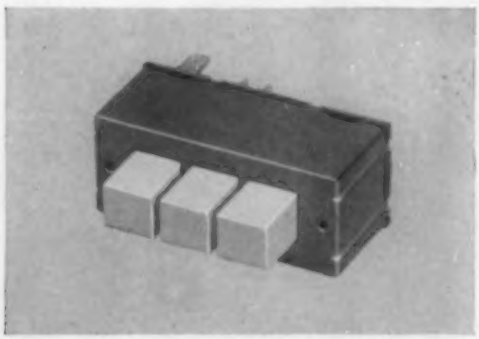
Model 3100 single section bakelite switch; up to 12 positions, 30° indexing, with 1¼" diameter base; up to 18 positions, 20° indexing, with 1 11/16" base.



Model RL switch: multiple section bakelite wafer switch with solid silver contact slugs; up to 12 positions per section with 30° indexing, 6 positions per section with 60° indexing.



Interval Timer Switches: universal design provides flexible arrangement for as many as 16 circuits to be switched in accurate sequence.



Push Button Switch: 3 button switch for medium power applications.

For top performance switches

Expect more . . . Get more from

Serving Industry with These Products:

Electromechanical—Resistors • Switches • Television Tuners • Vibrators
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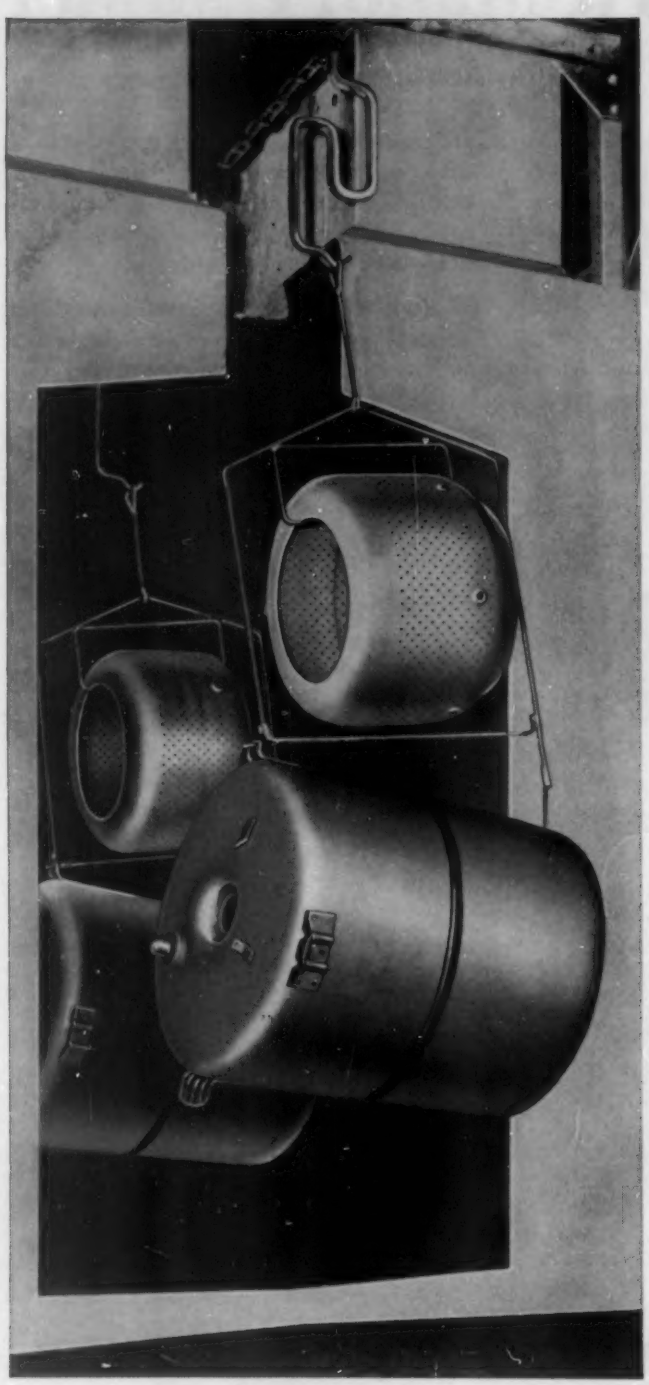
P. R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

HOT H_2SO_4 Corrosion Stopped COLD

by *Carpenter*

Stainless No. 20Cb



Appliance Manufacturer Eliminates Pickling Tank Maintenance Costs

70,000 lbs. of steel parts for automatic washing machines are cleaned daily by a 10% hot sulphuric acid solution at stage five in a nine-stage continuous pickling machine. Taming the H_2SO_4 solution is a 20′x9′x4½′ spray booth lined with Carpenter Stainless No. 20Cb plate.

Rubber lining previously used resulted in frequent and costly breakdowns. Carpenter Stainless No. 20Cb requires no maintenance and shows no sign of corrosive attack after lengthy use. Heating coils submerged in the H_2SO_4 solution, as well as nozzles for the spray system, are also made of this super corrosion-resistant alloy.

Carpenter Stainless No. 20Cb gives cost-cutting freedom from corrosive attack by a long list of other acids, liquids and gases.

See how pipe, tubing, sheet, plate, bar, wire or strip of Carpenter Stainless No. 20 or 20Cb can help you cut corrosion costs. Send now for the NEW Carpenter Stainless No. 20 and No. 20Cb handbook.

MEMBER

The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Carpenter

Stainless Tubing & Pipe

For information on Carpenter Stainless No. 20 strip, wire, billets, contact The Carpenter Steel Company, Reading, Pa.

use 'dag' dry films for trouble-free lubrication

Where the lubrication of inaccessible mechanisms will surely be neglected . . . when you cannot be certain of regular maintenance . . . 'dag' dispersions can be used to give your product *lifetime dry-film lubrication.*

'dag' Colloidal Graphite is high-purity electric-furnace graphite, treated to produce micron-size particles and dispersed in many paste and liquid carriers. As a lubricant it is chemically inert; it is insoluble in acids, alkalies, or solvents; it is electrically conductive. 'dag' Colloidal Graphite forms durable, tenacious, *dry lubricating films* which are not affected by temperatures up to 750°F. and which are equally effective under sub-zero conditions.

The popular new solid lubricant, molybdenum disulfide, is also available in various dispersions for specialized lubricating problems. 'dag' dispersions are easily applied by spraying, brushing, or dipping.

You'll find a surprising number of ways to use 'dag' dispersions described in our free booklets: High-Temperature Lubrication; Surface Coatings and Impregnation; and Dry-Film Lubrication. Write for Bulletins No. 423-W8, No. 435-W8, and No. 438-W8.

We are equipped to do custom dispersing of solids in a wide variety of carriers.

You can design for lifelong lubrication with 'dag' dispersions

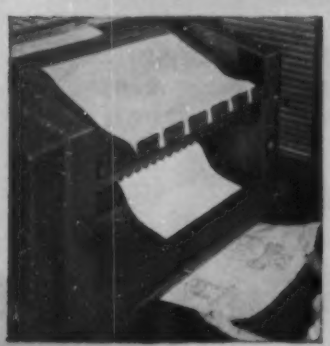
ACHESON COLLOIDS COMPANY

PORT HURON, MICHIGAN

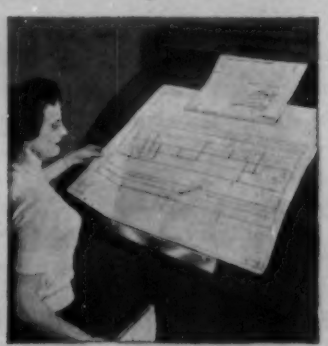
...also ACHESON COLLOIDS LIMITED, LONDON, ENGLAND

New, High-Speed,
Heavy-Volume Copyflex Model 500
$3250.00 f. o. b. Chicago
40 f.p.m. speed, 200-230 volt operation, 46-inch printing width

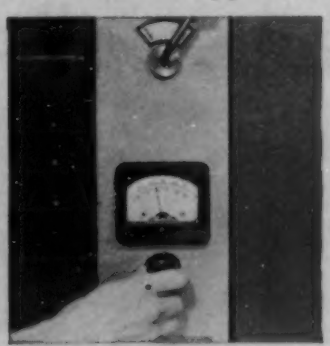
Here Are the New, Outstanding Features That Make New Copyflex Model 500 Your Best Buy



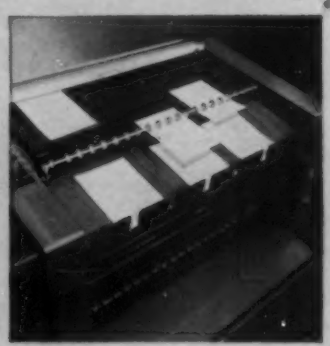
Bigger and better front delivery tray takes up to 24″ x 42″ prints, allows more efficient stacking, speeds production.



Larger rear delivery tray handles up to 30″ x 42″ prints. Movable magnetic stops provide variable rear stacking.



Model 500 provides fast 40 f.p.m. speed. New type indicator shows actual speed, permits more efficient operation.



Variable front print stacker (optional) is a Bruning exclusive. Control knob gives desired stacking size from 6″ to 24″.

NEW!

Here it is! The faster, easier-to-use, lower-priced reproduction machine they said couldn't be built!

COPYFLEX MODEL 500

It's another Bruning *first* for you—a more efficient, faster, heavy-volume Copyflex machine that has been built to sell at the low price of $3,250.00 f.o.b. Chicago. It's another first for Bruning engineers and production men who doubted it could be done but who came up with remarkable engineering innovations to do it!

New, modern Copyflex Model 500 gives you *all* the advantages of Copyflex diazo type whiteprinting, provides equal or greater capacity than much higher-priced machines, offers new and better operating features to help you turn out more work at less cost.

NEW . . . Better Stacking and Delivery!

Large front tray takes prints up to 24 x 42 inches. Large rear tray takes sizes up to 30 x 42 inches. Extra roomy tracing tray further speeds operator's work. Movable magnetic stops in rear tray provide efficient variable stacking. A special tracing stacker, a variable front print stacker, and a print roll-up attachment are available as optional equipment at extra cost.

NEW . . . Positive "Jet-Separation" of Tracings!

A new, patented air-jet type separator device provides automatic positive separation of tracings from exposed sheets, speeds operator's work.

NEW . . . 40 f.p.m. Mechanical Speed!

With a mechanical speed of 40 linear feet per minute, Copyflex Model 500 gives you fast, heavy volume production. Its 4,000-watt quartz lamp and synchronized exposure and developer units assure uniformly sharp, clear prints.

NEW . . . Trouble-free, Selenium Rectifier Drive Controls!

The electrical control system of the Model 500 is free from vacuum tubes, a common source of trouble in most other machines. Use of such devices as variable transformers and 100,000-hour-life rated selenium rectifiers assure efficient, trouble-free operation.

PLUS . . . the famous Problem-free Installation and Operation of Copyflex!

Like all other Copyflex machines, Model 500 is free from fumes and odors, requires no exhaust venting, plumbing, or auxiliary equipment other than an electrical connection.

It is a virtually automatic machine that is easy to operate. Exclusive vacuum feed enables easy insertion of curled originals. Adjustable light shield provides extra convenience and economy in processing extra-fast-printing originals. A special foot treadle allows operator to withdraw or straighten any work which has been fed incorrectly.

All of the famous Copyflex advantages, plus new modern features, are yours in the amazing lower-priced Copyflex Model 500. Take this opportunity to trade in that old machine. Mail coupon today. You owe it to yourself and to your company!

on the Market Today!

Special tracing stacking device (optional) provides efficient stacking of various size originals, up to 12".

Print roll-up device (optional) at rear of machine affords fast, efficient handling of continuous roll stock work.

BRUNING

Specialists in Copying Since 1897

CHARLES BRUNING COMPANY, INC.
4700 Montrose Ave., Chicago 41, Illinois

Charles Bruning Company, Inc., Dept. 1514
4700 Montrose Ave., Chicago 41, Illinois

Please send me information on the new Copyflex Model 500.

Name_____ **Title**_____

Company_____

Address_____

City_____ **County**_____ **State**_____

Engineered and fabricated by Regal Plastic Company, Kansas City, Missouri.

Lightweight and Leakproof

Another Case for U. S. Royalite!

The Breuer Electric Manufacturing Company *had* the solution. All they needed was something to *hold* it in!

Something that would be unaffected by the shampoos and other chemical solutions used with their "Tornado" floor machines...

- ...that would be easy to fabricate and relatively inexpensive to produce.
- ...that would contribute to the modern appearance and efficiency of the machine.
- ...that *would not break or leak* when subjected to the rough use this powerful, versatile worker had to take.

All they needed was U. S. Royalite!

When they switched to U. S. Royalite for their solution tanks, they found it far less costly to fabricate than the formed metal previously used. And it *required no expensive finishing operations.* (The two halves are draw-formed separately, reinforced with bosses and flanges for threaded attachments, and liquid welded together. A transparent plastic inset shows fluid level.)

And though extremely light, this U. S. Royalite plastic tank is so rugged that it's brought *complete customer satisfaction in three years of grueling service.*

If you have a solution that needs a case, perhaps you *too* will find the answer in U. S. Royalite. Why not write to us and find out?

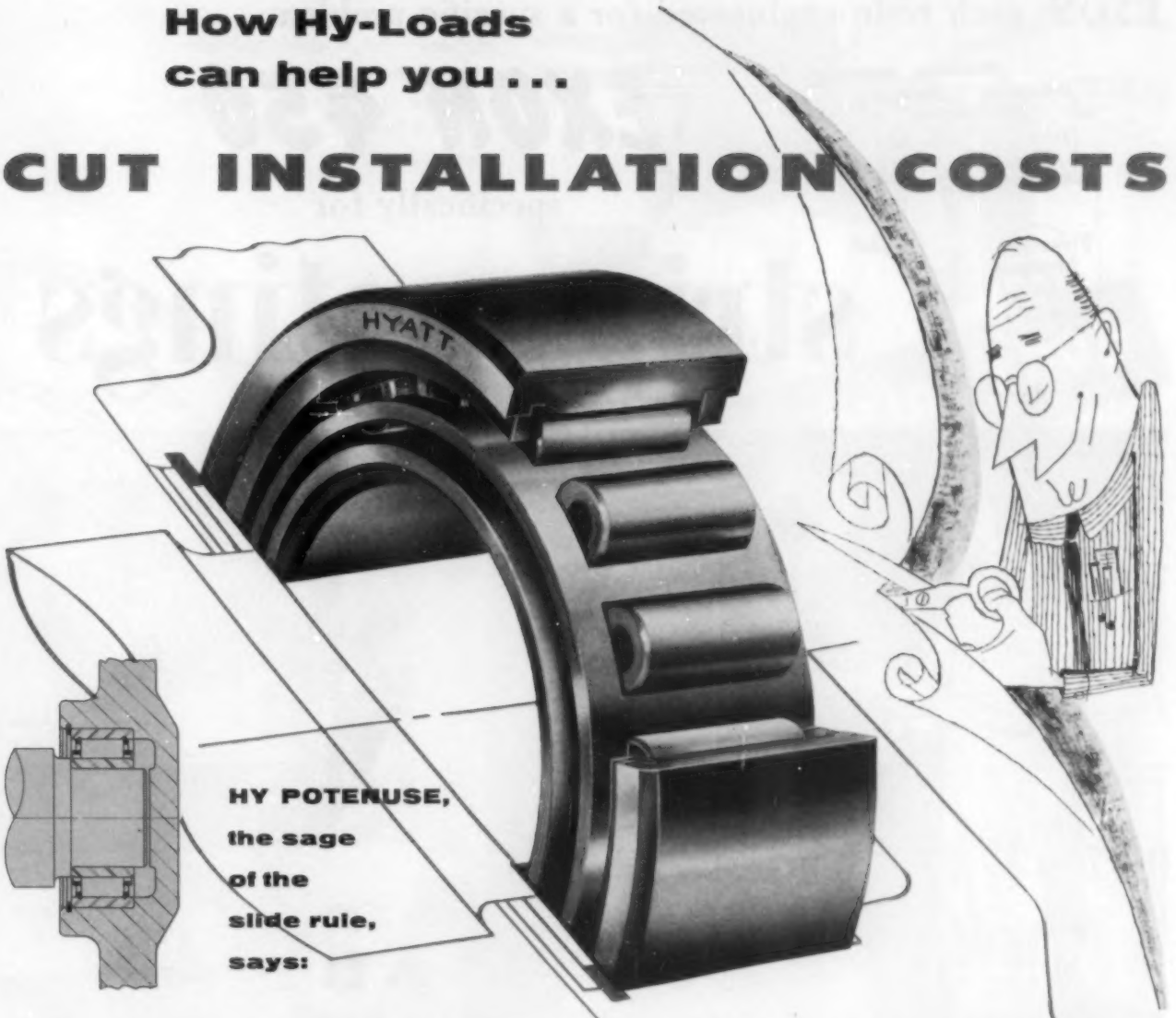
U.S. ROYALITE®
TOUGH, VERSATILE FABRICATING MATERIAL

US RUBBER

UNITED STATES RUBBER COMPANY
2638 NORTH PULASKI ROAD, CHICAGO 39, ILLINOIS

How Hy-Loads can help you . . .

CUT INSTALLATION COSTS



You don't need a lot of extra "holding gimmicks" with HYATTS!

YOUR COMPLETE LINE OF CYLINDRICAL ROLLER BEARINGS

Look at this speed reducer, for instance. The inner race of the HYATT Hy-Load is held on the shaft with a heavy press or shrink fit—*nothing more!* No money wasted for end clamps, threads, nuts, screws or washers. And brother, that rotating HYATT race will *never crack or come loose* come h - - - or high water. Know why?

HYATT races are made from low carbon alloy steel which, after carburizing, provides a *ductile core* and *case hardened operating surfaces.* That's why they'll take press fits and shock loads that would be suicide for the through-hardened steel used by other bearing makers. Naturally, it costs HYATT more to maintain the industry's finest heat-treating facilities that make this extra quality possible—*but it sure saves trouble and money for every HYATT user!* Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.

HYATT ROLLER BEARINGS

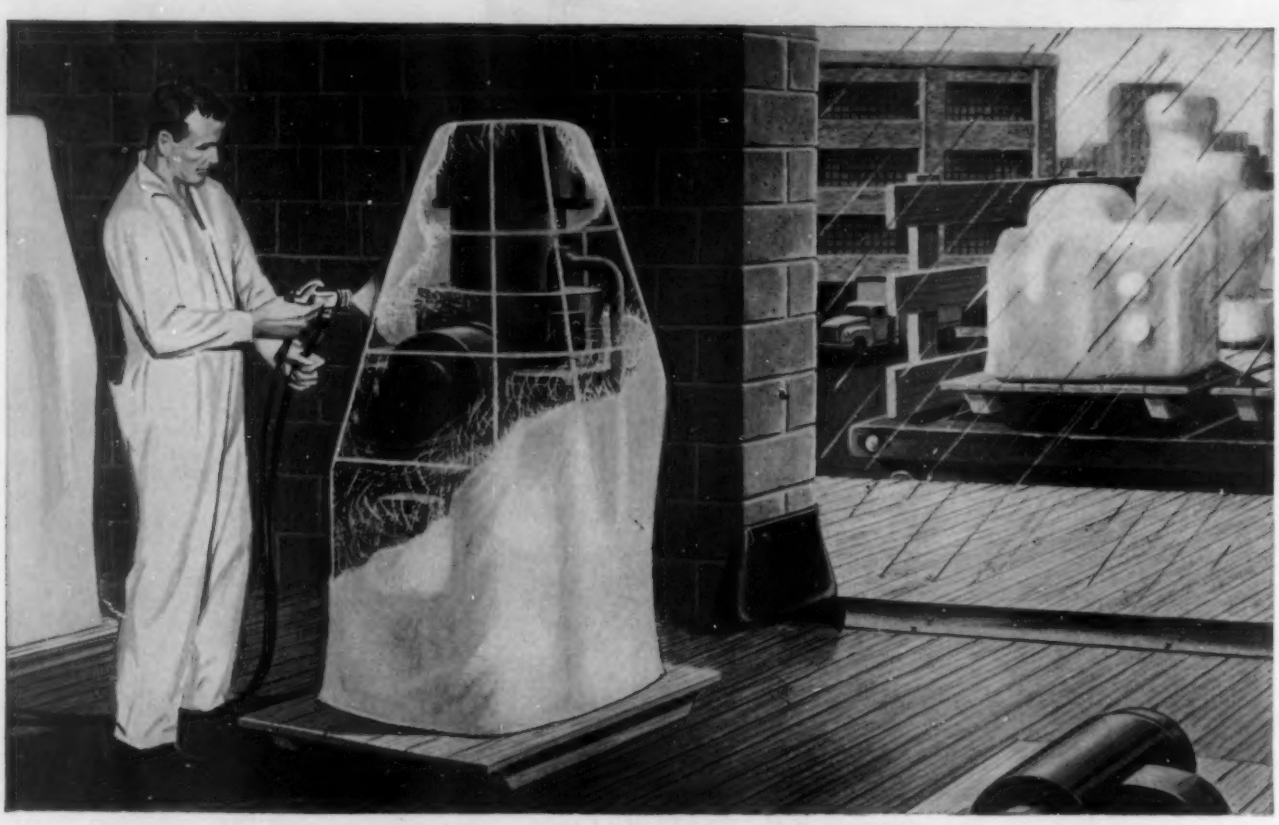
STRAIGHT BARREL TAPER

EXON: each resin engineered for a specific problem

EXON 450

specifically for

strip coatings



Using one resin instead of two spells economy for compounders of strippable vinyl coatings. New EXON 450 makes this possible. It simplifies compounding techniques because this one resin provides good solubility, film tensile strength and durability in the formulations based on it.

To assure product protection from dust, dirt, moisture, grease and weathering —both industry and government* are making extensive use of spray-applied vinyl wrappings made with EXON 450.

Easy to use, easy to remove! Strip coatings made from EXON 450 can be spray-applied from various solvent combinations and require no further maintenance. When the coating is stripped or peeled off, the product is left clean and ready for immediate use.

For complete information or technical service on the ever-growing line of EXON resins, call or write:

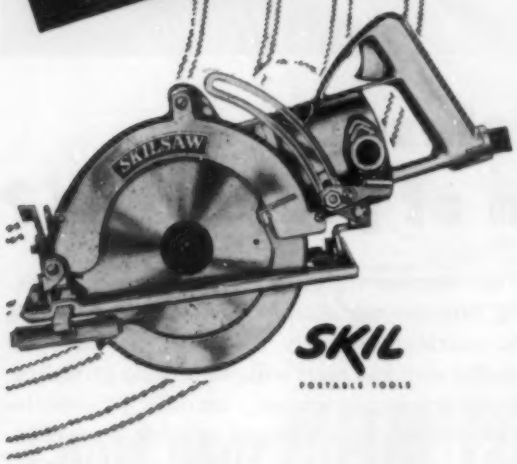
Firestone

*EXON 450 meets Government Specification MIL-B-12121

CHEMICAL SALES DIVISION
FIRESTONE PLASTICS COMPANY, POTTSTOWN, PA., DEPT. 5M
DIVISION OF FIRESTONE TIRE & RUBBER CO.

Color printing demands exacting precision, vibration-free press performance for accurate register of one color to the next. You'll find Federal Bearings here, too.

in the workshop . . . or the print shop



High operating speeds . . . heavy, suddenly applied radial and thrust loads . . . little maintenance or none at all—they're all part of the service conditions Federal Ball Bearings meet in power hand tools.

so much of industry *turns* on FEDERAL ball bearings

In hobbyists' tools and home appliances—in pressrooms and mass-production plants—in farm equipment and business machines—you'll find Federal Ball Bearings quietly and efficiently at work, in some of the hundreds of types and 12,000 sizes that the company has been producing for almost 50 years devoted *only* to making ball bearings.

When Federal Ball Bearings are a part of so many things you *use*, shouldn't they be a part of the things you make?

THE FEDERAL BEARINGS CO., INC. • POUGHKEEPSIE, N. Y.

175 fact-packed pages of information on ball bearings are yours for the asking in Federal's Catalog. Just drop us a line for your copy.

Federal BALL BEARINGS

One of America's Largest Ball Bearing Manufacturers

Looking for a Stainless Steel with a *New* combination of properties?

Here is a radically different chrome-nickel stainless developed by Carpenter to give you this unusual combination of fabricating and product benefits . . .

. . . work hardens *much slower* than any of the conventional 18-8 grades

. . . remains *non-magnetic* after severe cold working

. . . possesses corrosion resistance *equal to* or *better than* standard chrome-nickel stainless steels

This unusual combination of advantages is one reason why Carpenter *Stainless No. 10* is earning a unique place among engineered materials.

For example, it has opened whole new fields of applications in the fastener industry. With its slower work-hardening, fastener manufacturers can now produce on automatic machines severely cold headed and upset chrome-nickel stainless parts without process annealing. *No. 10* is also proving its economy on other jobs involving difficult coining, extrusion and swaging operations.

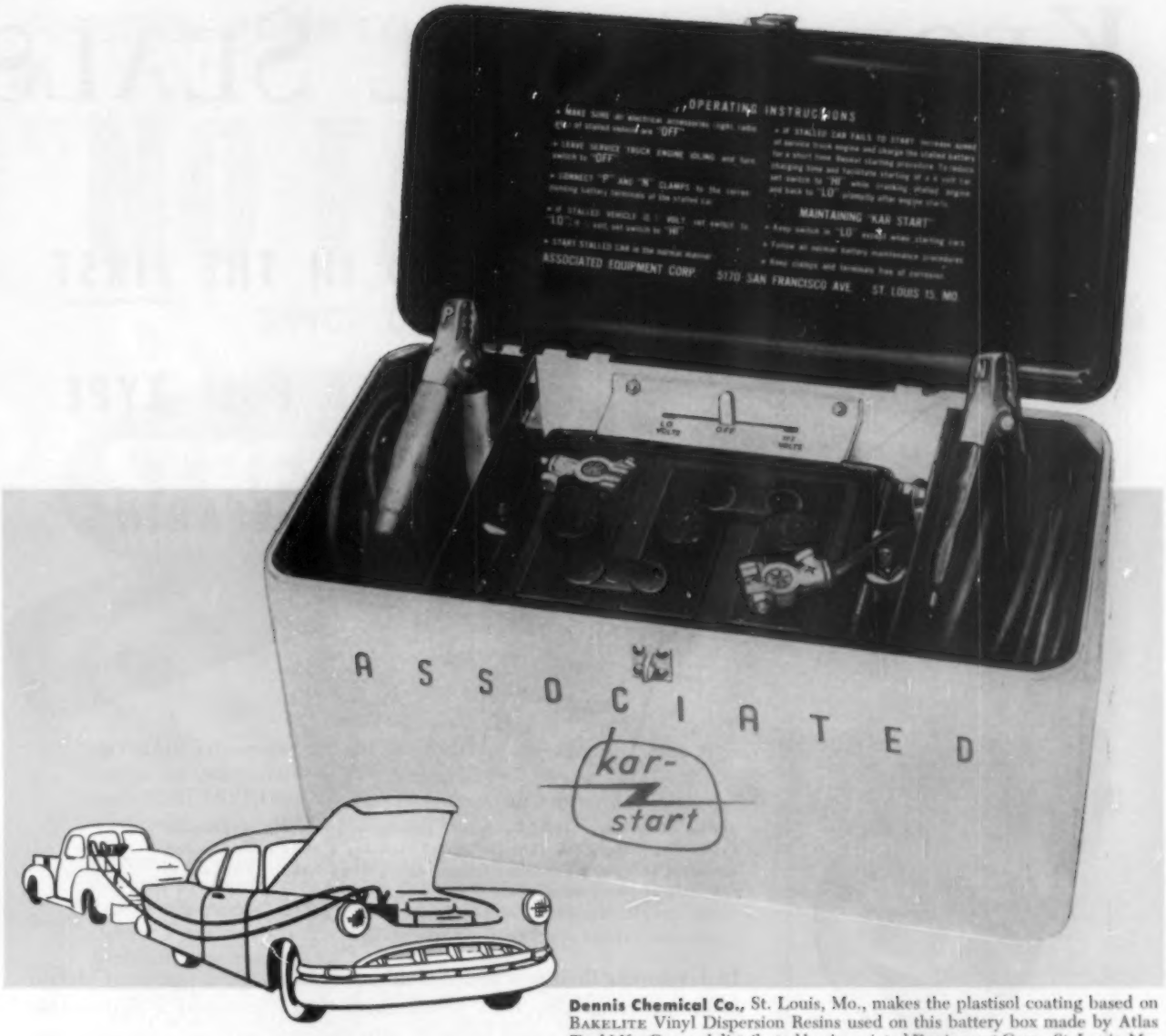
Another example is instrument parts which must remain non-magnetic after fabrication. After a 50% reduction, with a field of 200 Oersteds, permeability is about 1.002. After an 80% reduction: about 1.018. Will you be *next* to benefit from *Stainless No. 10?* How can *your* stainless product be improved, production simplified, costs lowered? Get the complete story on *No. 10.* Just drop us a line on your Company letterhead. THE CARPENTER STEEL CO., 117 W. Bern St., Reading, Pa.

Carpenter STEEL

Stainless No. 10

take the problems out of production.

Pioneering in Improved Tool, Alloy and Stainless Steels Through Continuing Research
Export Department: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"



Dennis Chemical Co., St. Louis, Mo., makes the plastisol coating based on BAKELITE Vinyl Dispersion Resins used on this battery box made by Atlas Tool Mfg. Co., and distributed by Associated Equipment Corp., St. Louis, Mo.

Could your METAL COATINGS meet this "battery test"?

When autos stall, this tow-car battery kit starts them. It consists of a storage battery and two 20-foot cables, all carried in a chest coated inside with plastisol based on BAKELITE Brand Vinyl Dispersion Resins.

Think of the service conditions . . . Weather extremes. Moisture. Corrosion. Acid spillage. Rough handling. Ask yourself whether any of your present metal coatings could endure such abuse.

This plastisol coating is applied over a one-coat primer that can bond it fast to steel, copper, brass, aluminum, or galvanized iron. Soft and rubbery, the plastisol cushions the load and acts as electrical insulation, besides protecting the metal chest. It can be formulated for application by dip or spray . . . can form a coating that's soft, resilient, and decorative, or hard, tough, and thick. Slush-molded plastisol based on BAKELITE Vinyl Dispersion Resins forms the clamp grips in this kit.

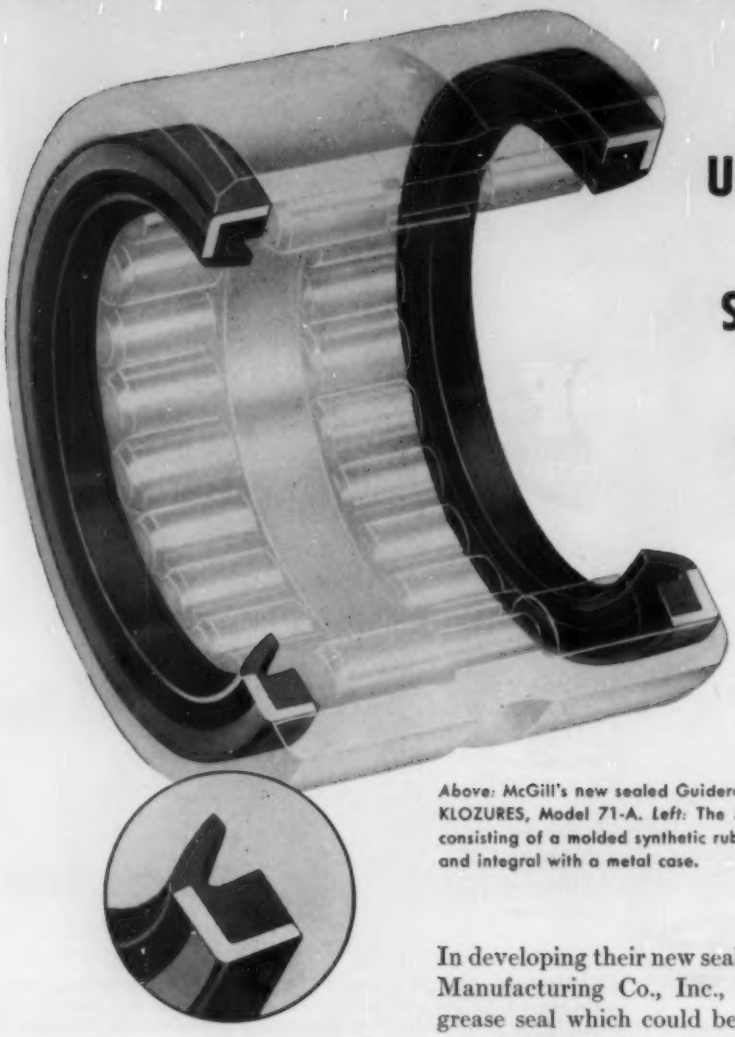
To finish the story, the outside of the chest is protected by a spray coating based on BAKELITE Vinyl Resins—making the job 100% vinyl coated. If you want protective coatings like these, investigate by writing Dept. CB-10.

BAKELITE BRAND Vinyl Dispersion Resins

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

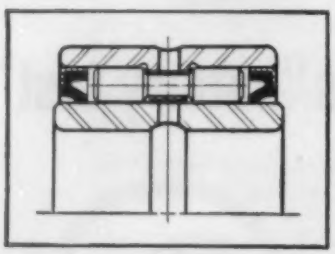
The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC

KLOZURE* OIL SEALS



USED IN THE FIRST SEALED FULL TYPE ROLLER BEARING

Above: McGill's new sealed Guiderol** bearing with two *built-in* springless KLOZURES, Model 71-A. *Left:* The Model 71-A has a narrow cross section consisting of a molded synthetic rubber sealing member securely bonded to and integral with a metal case.



Two springless KLOZURES, lips turned in, on Guiderol bearing provide lifetime retention of lubricant. For re-lubricating at high pressures other sealing arrangements (with lips turned out; with one lip in and one out; and single seals) are available with these bearings.

In developing their new sealed Guiderol bearing, the designers of McGill Manufacturing Co., Inc., (Valparaiso, Ind.) required a dependable grease seal which could be built into the unit *without* increasing the overall bearing size.

Springless KLOZURE Model 71-A proved to be the answer! For here was a proven grease seal of narrow cross section specifically designed for limited space applications. Here, also, was a trouble-free seal which would keep out dust and retain the lubricant for the *life of the bearing.*

There's a service tested KLOZURE model for every bearing application. Let us show you how Garlock KLOZURES can solve your sealing problems. Just call the Garlock office nearest you or write for KLOZURE Catalog 10.

THE GARLOCK PACKING COMPANY, PALMYRA, N.Y.

Sales Offices and Warehouses: Baltimore • Birmingham • Boston • Buffalo • Chicago Cincinnati • Cleveland • Denver • Detroit • Houston • Los Angeles • New Orleans • New York City • Palmyra (N.Y.) • Philadelphia • Pittsburgh • Portland (Oregon) • Salt Lake City • San Francisco • St. Louis • Seattle • Spokane • Tulsa.

In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.

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**Trademark of the McGill Manufacturing Co., Inc.

GARLOCK

PACKINGS, GASKETS, OIL SEALS, MECHANICAL SEALS, RUBBER EXPANSION JOINTS

TUTHILL PUMP COMPANY EXPERIENCES...

"NO FAILURES

SINCE USING

SAVES MONEY, TOO!"

●Tuthill knows the rotor is the heart of their pump. Quality cannot be compromised. For more than 10 years, Tuthill has used STRESSPROOF for rotors (replacing heat-treated alloy steel) without a failure!

Strength is required in these rotors to transmit the power through the shaft to the idler gear. Extremely high operating speeds mean the rotors must be straight. Wearability is an absolute necessity if the rotors are to stand up under severe operating conditions.

STRESSPROOF has all of these qualities. In addition, it is readily machinable. Its in-the-bar strength eliminates heat treating with its distortion, cleaning and subsequent machining problems. No rough machining, heat treating and finish machining with STRESSPROOF. The rotors are finish-machined from the bar.

STRESSPROOF's minimum warpage eliminates all straightening operations in this case. Its wearability keeps the rotor running year after year. It also provides real savings in both material and manufacturing costs.

STRESSPROOF makes a better part at a lower cost.

Tuthill Model L Series mechanically sealed pumps are used in lubricating, hydraulic, transfer and burning oil service. Capacities range from ⅓ to 6 g.p.m. at pressures up to 600 p.s.i. The rotors for these dependable industrial pumps are made from La Salle STRESSPROOF.

WRITE TODAY FOR

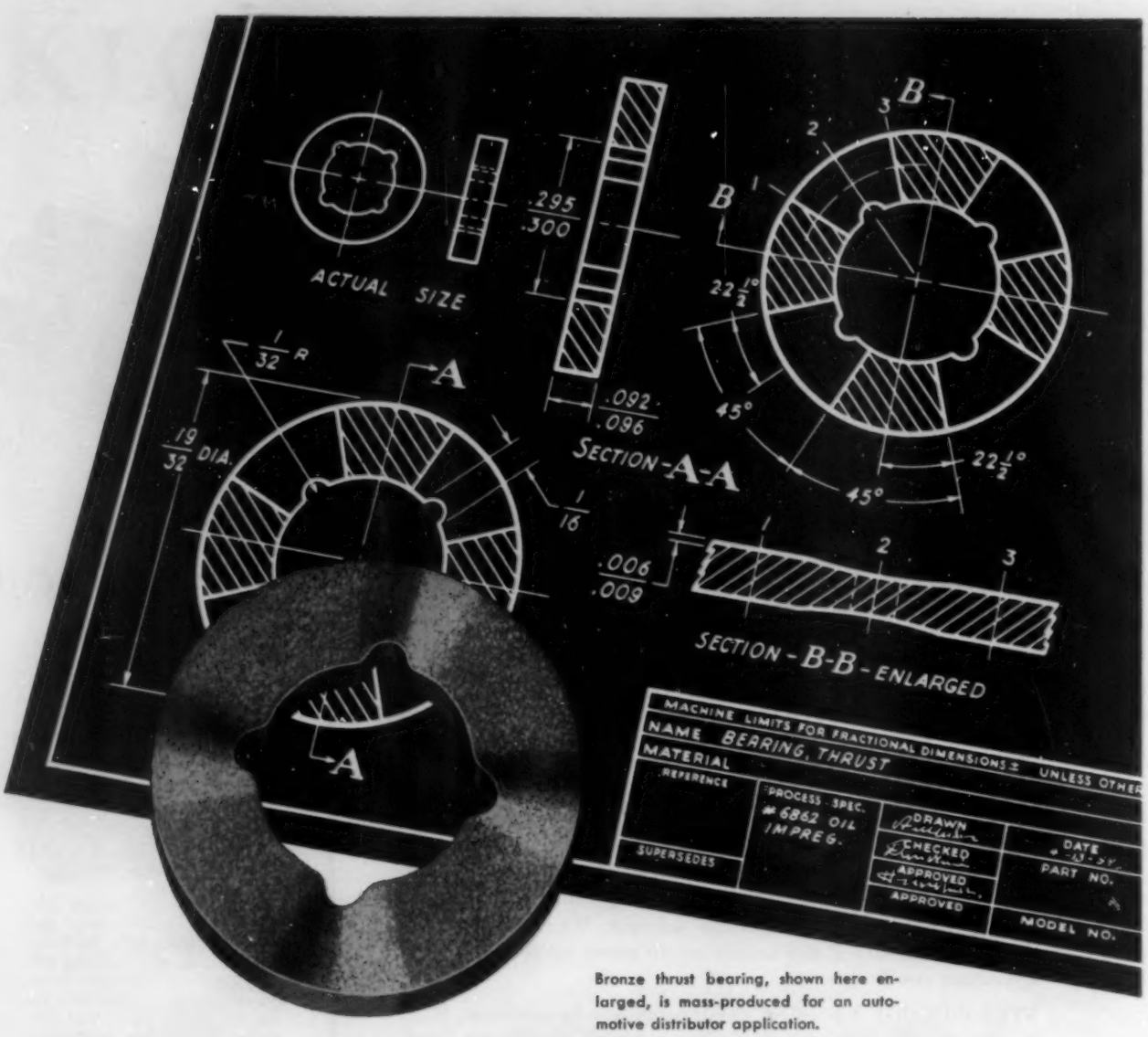
helpful data bulletin No. 15... "Improve Quality — Cut Costs"

AVAILABLE FROM LEADING STEEL DISTRIBUTORS COAST-TO-COAST

La Salle STEEL CO.

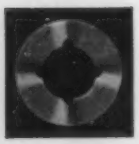
1430 150th Street, Hammond, Indiana

MANUFACTURERS OF AMERICA'S MOST COMPLETE LINE OF QUALITY COLD-FINISHED STEEL BARS



Bronze thrust bearing, shown here enlarged, is mass-produced for an automotive distributor application.

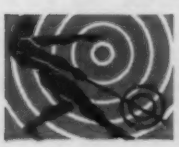
MORAINE'S EXPERIENCE WITH METAL POWDER HELPS MANY MANUFACTURERS



Whether it's this small thrust bearing or a large, highly complex part, the odds are that it can be produced at lower cost by the Moraine metal powder process when it is to be produced in quantity.

Each week sees new proof of what can be accomplished by cooperative effort between customers and Moraine. Simplified production, improved performance and reduced cost are three of the results that now benefit many different industries.

In powder metallurgy, Moraine has unequaled experience. Facilities are unexcelled. Whether in production or in planning, the Moraine metal powder process may be able to help you make your product better, at lower cost.



moraine products
DIVISION OF GENERAL MOTORS, DAYTON, OHIO

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Any Holo-Krome distributor in the nation can give you a brand of service never before enjoyed by users of socket screw products . . .

Because Holo-Krome ships all standard catalog items right from stock the same day the order is received!

What about Specials? We're proud to say that even the "impossible" ones are leaving the H-K plant in 4 weeks or better — mostly better!

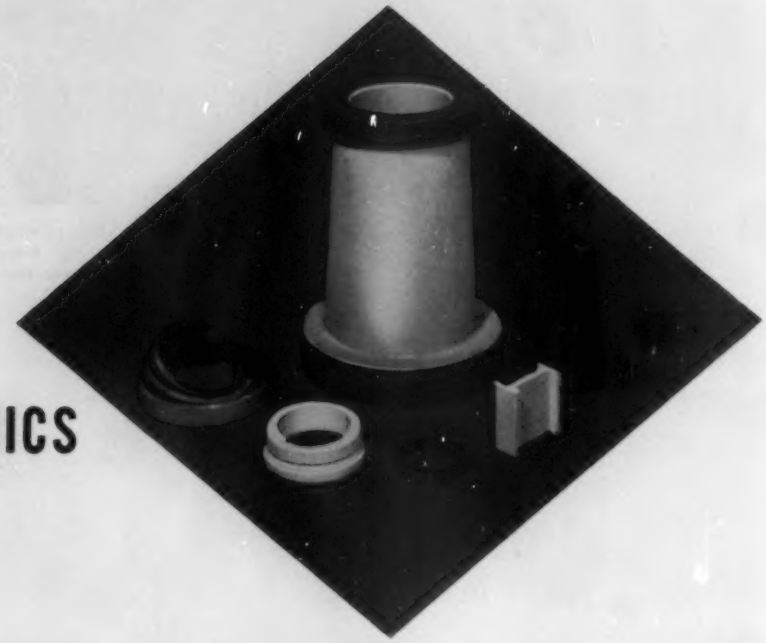
Every day, more and more people specify Holo-Krome — because the price is right, the delivery's right and the quality's always Best!

We guarantee it! Next time, just say . . . HOLO-KROME!

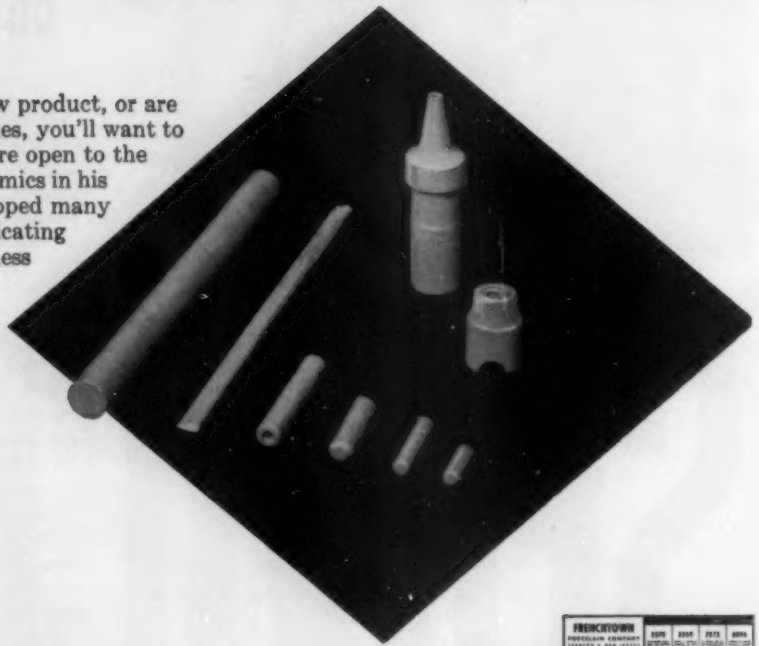
HOLO-KROME
Completely Cold Forged
SOCKET SCREWS

THE HOLO-KROME SCREW CORP. • HARTFORD 10, CONN., U. S. A.

FRENCHTOWN ENGINEERED CERAMICS OFFER



big advantages!

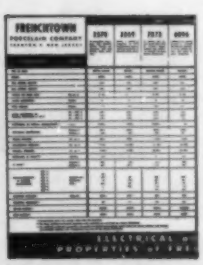


Whether you plan the development of a new product, or are seeking ways to further improve existing ones, you'll want to look into the many new possibilities which are open to the design engineer who includes *engineered* ceramics in his planning. Our ceramic engineers have developed many formulae which, together with modern fabricating methods,* have greatly enlarged the usefulness of these amazing materials. Always outstanding as electrical insulators, Frenchtown ceramics, particularly the high alumina bodies, are being specified more and more for critical mechanical applications.

Check these BIG advantages:

- MECHANICAL STRENGTH
  Compressive strength up to 187,000 psi.
- ABRASION RESISTANCE
  Demonstrated by use for sand blast nozzles.
- HEAT RESISTANCE
  Softening temperatures up to 1971° C.
- THERMAL CONDUCTIVITY
  Coefficient (c.g.s. units) up to 0.0180.
- THERMAL EXPANSION
  as low as 2% cumulative at 700° C.

**Grinding and extrusion facilities* • NICOTE® *Metallized Ceramics*



Send for this helpful bulletin giving complete data on mechanical and electrical properties of all Frenchtown Engineered Ceramics.

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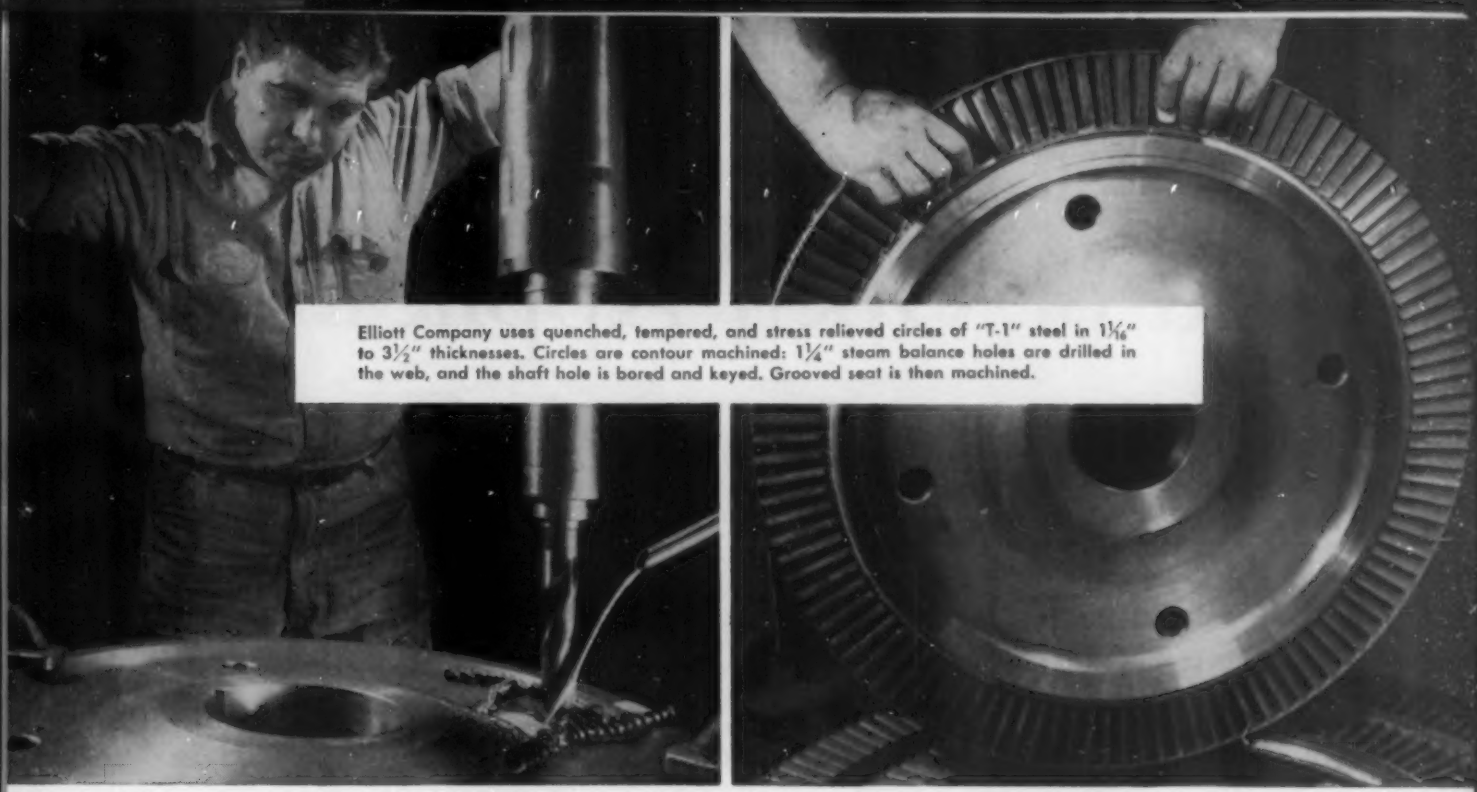

Elliott Company uses quenched, tempered, and stress relieved circles of "T-1" steel in 1 1/16" to 3 1/2" thicknesses. Circles are contour machined: 1 1/4" steam balance holes are drilled in the web, and the shaft hole is bored and keyed. Grooved seat is then machined.

New USS "T1" Steel cuts material cost 60%

in rotor discs of small turbines

Provides high strength at high temperature, and stability at high speed of rotation

• The Elliott Company, Jeannette, Pennsylvania, makes industrial steam turbines for driving pumps, fans, blowers, and other rotating equipment. The steel for the turbine discs must withstand high stresses at high temperatures and at speeds as high as 6,000 rpm. It must be sound throughout. That's why Elliott Company has switched to new USS "T-1" Steel in these discs.

"T-1" provides a minimum yield strength of 90,000 psi. and good creep rupture strength to 900°F. It poses no severe fabrication problems. What's more, "T-1" costs 60% less in this turbine application than the alloy steel previously used. And the switch to "T-1" required no change in design.

Although USS "T-1" Steel is comparatively new, it already has proved well suited to a great variety of applications. In addition to great high-temperature strength, it has extraordinary toughness at temperatures far below zero. It has excellent resistance to impact abuse, impact abrasion, and atmospheric corrosion. By taking advantage of these superior properties, you can reduce the size and weight, increase the strength and durability, and reduce the cost of such varied equipment as pressure vessels, power shovels, draft lines, storage tanks, conveyors, bridges, and towers. Where field fabrication or repairs are necessary or desirable, "T-1" cuts costs still further because it can be welded or flame cut either in shop or field without pre-heating or stress relieving.

Send the coupon for complete information.

United States Steel, Room 4701
525 William Penn Place
Pittsburgh 30, Pa.

☐ Please send me your booklet, "United States Steel presents T-1" which contains the full story of "T-1" steel.

☐ Have your representative get in touch with me.

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City.....State.....

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USS "T1" CONSTRUCTIONAL ALLOY STEEL

USS

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UNITED STATES STEEL

(*Advertisement*)

Riveting With a Hammer in Blind or Open Applications

Elimination of special riveting tools can mean faster production, lower costs, no down time.

J. K. BARRY, M. E.

The use of blind rivets installed with only an ordinary hammer from one side of the job offers a highly simplified method of fastening. Speed, convenience and *low installed cost* make Drive Riveting preferable not only for blind joints, but for fastening many parts that can be reached from either side.

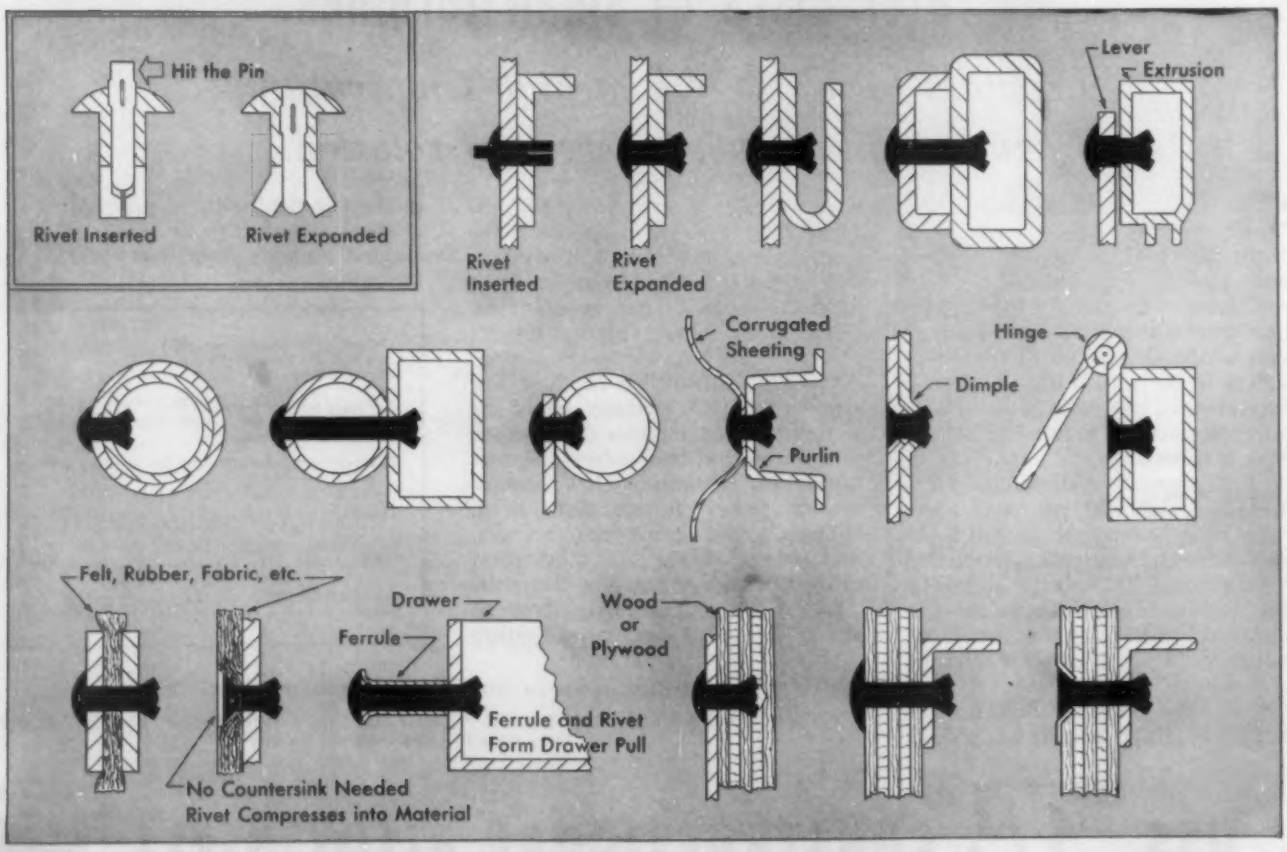
The Southco Drive Rivet has a cored, slotted body with a grooved pin protruding from its head. When the rivet is inserted through parts to be fastened, the pin is driven flush with the rivet head causing the expanding prongs to form a blind head behind the rear sheet. No further finishing is necessary, since the pin seats itself permanently to complete the smooth head contour.

Drive Riveting has five major advantages:

1. No investment in special tooling.
2. No lost time for tool repairs.
3. No limitation on the number of men who can install rivets.
4. Speed comparable to nailing.
5. Only one man is needed.

Widely used in truck bodies, storm doors, metal buildings and hundreds of other industrial applications, Southco Drive Rivets make a secure, vibration-proof joint. A wide range of head styles, diameters and grip lengths is available.

RECOMMENDED APPLICATIONS FOR DRIVE RIVETING



SOUTHCO Division, South Chester Corporation, 236 Industrial Hwy., Lester, Pa.

Built stronger, tougher and lighter with USS MAN-TEN Steel

Famous HYSTER Logging Arch handles more footage faster

In this "packaged" logging unit, consisting of a Hyster Arch Towing Winch and Caterpillar Diesel Tractor, the objective of the engineers was to produce equipment having the highest degree of mechanical efficiency, plus durability and speed of operation.

Because the key to profits is greater log production, which means that unnecessary breakdowns must be eliminated, extra margins of safety have been built into all parts subjected to stresses and wear.

By using USS MAN-TEN High Strength Steel in the arch boom, A-frame and tongue, it was possible to reduce weight of these important members by 10%, and yet to *increase* their strength-to-weight ratio over former construction.

The increased strength provided by MAN-TEN Steel gives the arch the ability to handle log loads of maximum size, and the reduced arch weight means greater mobility and maneuverability. Result: The operator can get into tight spots easier and pick up loads faster. Reduced weight also permits greater grade climbing ability in steeper terrain.

With USS High Strength Steels — USS MAN-TEN, USS COR-TEN and USS TRI-TEN—you can build extra strength and toughness into vital parts and ensure greater resistance to wear, fatigue, abrasion and impact.

Photographs courtesy of HYSTER COMPANY, Portland, Oregon

SOON TO BE ISSUED — Our new "Design Manual for High Strength Steels" contains comprehensive and practical information that you will find extremely useful in designing your equipment for greater economy and efficiency by the sound use of high strength steels. Watch our future advertisements for the announcement of the availability of this important publication.

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USS MAN-TEN HIGH Strength STEEL

USS

See "THE UNITED STATES STEEL HOUR"—Televised alternate weeks—Consult your newspaper for time and station.

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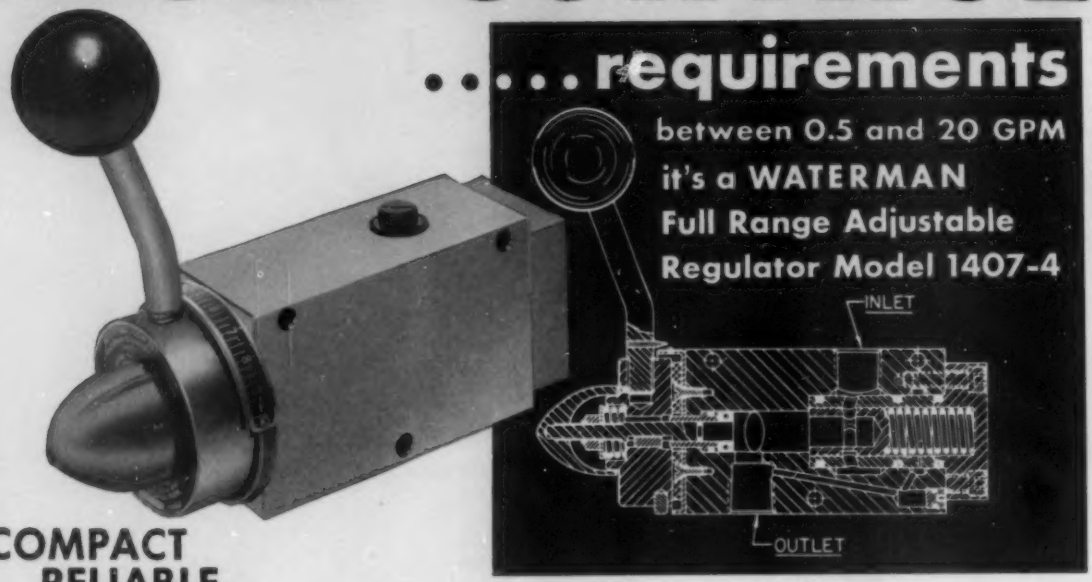
UNITED STATES STEEL

FOR YOUR
FLOW CONTROL



COMPACT
RELIABLE
RUGGED

Minimum to maximum flow adjustment obtained by 180° handle rotation.

Flow rate changes easily accomplished under any conditions of pressure or back pressure.

Adjustable handle tension eliminates need for wrenches and locking levers for changes in flow setting.

Ideally suited for installations requiring frequent changes in operating speeds or throttling control during the machine cycle.

Choice of control—either right or left rotation of control handle.

Multiple control—with right and left hand rotation operator can control two operations simultaneously.

Aluminum bodies housing steel working parts provide light weight units for easy handling and installation.

LOOK TO WATERMAN FOR THE ANSWER TO YOUR FLOW CONTROL REQUIREMENTS

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WATERMAN
ENGINEERING COMPANY
725 CUSTER AVENUE • EVANSTON, ILLINOIS

Stainless Steel bulb for color television tube by I-T-E Circuit Breaker Co., Philadelphia, Pa.

Spinning Stainless Steel circles into cone.

Forming cone on 500-ton hydraulic press.

How Stainless Steel helps I-T-E put color into television

Television is opening up a whole, wide wonderful world of color and Stainless Steel is playing an important part in this great advancement. I-T-E Circuit Breaker Company is manufacturing the bulb assembly for color television using cones made from Stainless Steel.

The advantages lie in the light weight made possible by metal shell construction—a highly important consideration at this stage of color tube development—the safety factor of a metal-glass tube and the ability to use a higher-quality glass in the picture surface. Stainless Steel's coefficient of thermal expansion makes it a suitable material for a metal-glass bond.

I-T-E's choice of Stainless Type 430 for its color TV development was a natural as they have produced millions of Stainless Type 430 cones for black and white picture tubes ranging from 8½" diameter sizes to 27" rectangulars.

Stainless Steel's unique combination of properties merits consideration in all types of design problems. And it's not a difficult material to fabricate. Investigate Stainless Steel for your products, and when you do, be sure to use service-tested USS Stainless Steel.

FABRICATING FACTS

For the bulb circles of USS Stainless Steel .125" thick are used. Circles are shear formed on a spinning lathe to produce a cone 21" in diameter, tapering to 8" by 14" deep.

Cone is further formed on 500-ton press. Panel is sheared from funnel, flanges are formed and deburred and both parts sandblasted to receive glass.

SEE The United States Steel Hour.
It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

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USS

USS STAINLESS STEEL

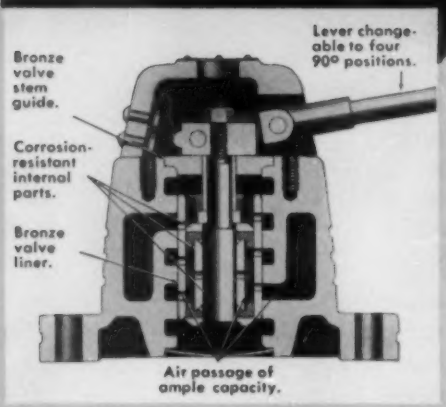
SHEETS • STRIP • PLATES • BARS • BILLETS • PIPE • TUBES • WIRE • SPECIAL SECTIONS

UNITED STATES STEEL

AIR POWER CAN BE COSTLY!

Eliminate breakdown and reduce maintenance by choosing Rivett Valves!

LONG LIFE ASSURED BY SIMPLE, COMPACT DESIGN


Lever changeable to four 90° positions.
Bronze valve stem guide.
Corrosion-resistant internal parts.
Bronze valve liner.
Air passage of ample capacity.

– at new low prices!

Flexibility for designing any circuit

Be confident of the continuous, uniform control of air by using any of the complete line of Rivett Air Valves. Design assures easy operation, long life — precludes need of adjustment—prevents leakage. Readily disassembled for servicing or modification.

Recommended for pressures up to 150 P.S.I., these valves are available in 5 sizes: ¼", ⅜", ½", ¾" and 1".

Get this important booklet!

Working drawings, specifications, cut-away views —all data requisite to good circuit layout in these 12 fact-filled pages. Write for free copy today!

RIVETT LATHE & GRINDER, Inc.
Dept. PE4 Brighton 35, Boston, Massachusetts

REPRESENTATIVES IN ALL PRINCIPAL CITIES

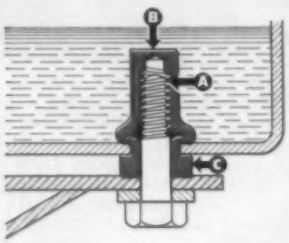
RIVETT furnishes a complete power package

AIR AND HYDRAULIC — VALVES, CYLINDERS, POWER UNITS

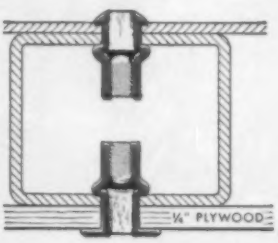
Member—National Fluid Power Association

One B. F. Goodrich Rivnut does two fastening jobs, cuts assembly cost!

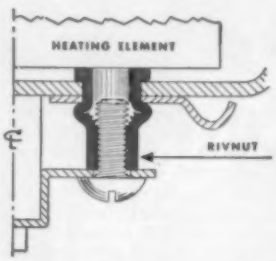
If you have fastening jobs like these, get B. F. Goodrich RIVNUTS



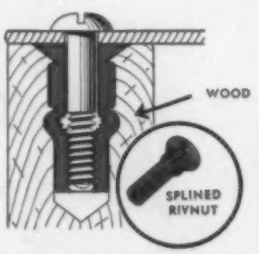
1. ELIMINATES BRAZING! Rivnuts with closed end (B) are installed in one-tenth the time it took to braze nut plates on oil reservoir tanks. Leaking, warping and thread cleaning are eliminated (A). Spacer head (C) positions tank.



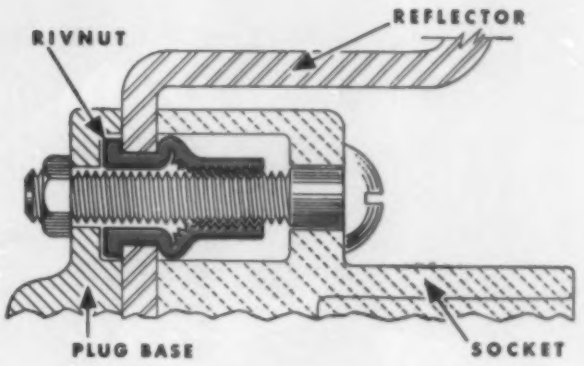
2. FASTENS PLYWOOD TO STEEL! Easier to install than wood or self-tapping screws, Rivnuts fasten plywood walls to tubular steel sections in trailers. No wood filler needed.



3. ELIMINATES REINFORCING PLATE! In assembly of vaporizers, Rivnuts do away with reinforcing plate, don't turn under torque, hold flange securely without bending. Result: less assembly time, fewer parts, better product.



4. GIVES 6 CLEAN THREADS IN WOOD! Rivnut upset in wood eliminates wood screws, provides 6 solid threads for attachment bolt. Bulge formed by upsetting holds Rivnut fast. Splined shaft keeps it from turning.



B. F. GOODRICH RIVNUTS cut assembly time and costs since they provide a firm, accurate nut plate in one quick operation. Welding, tapping are eliminated. Rivnuts can be installed from *one side* and can take an attachment bolt from either end.

In the application above (assembling spotlights) Rivnuts completely eliminated use of threaded studs which required welding in close quarters. They also eliminated a separate piercing and tapping operation and made it possible to attach nuts from the outside of the assembly instead of the inside. Rivnuts provided further cost savings since they could be attached *after* enameling without marring the finish of the unit.

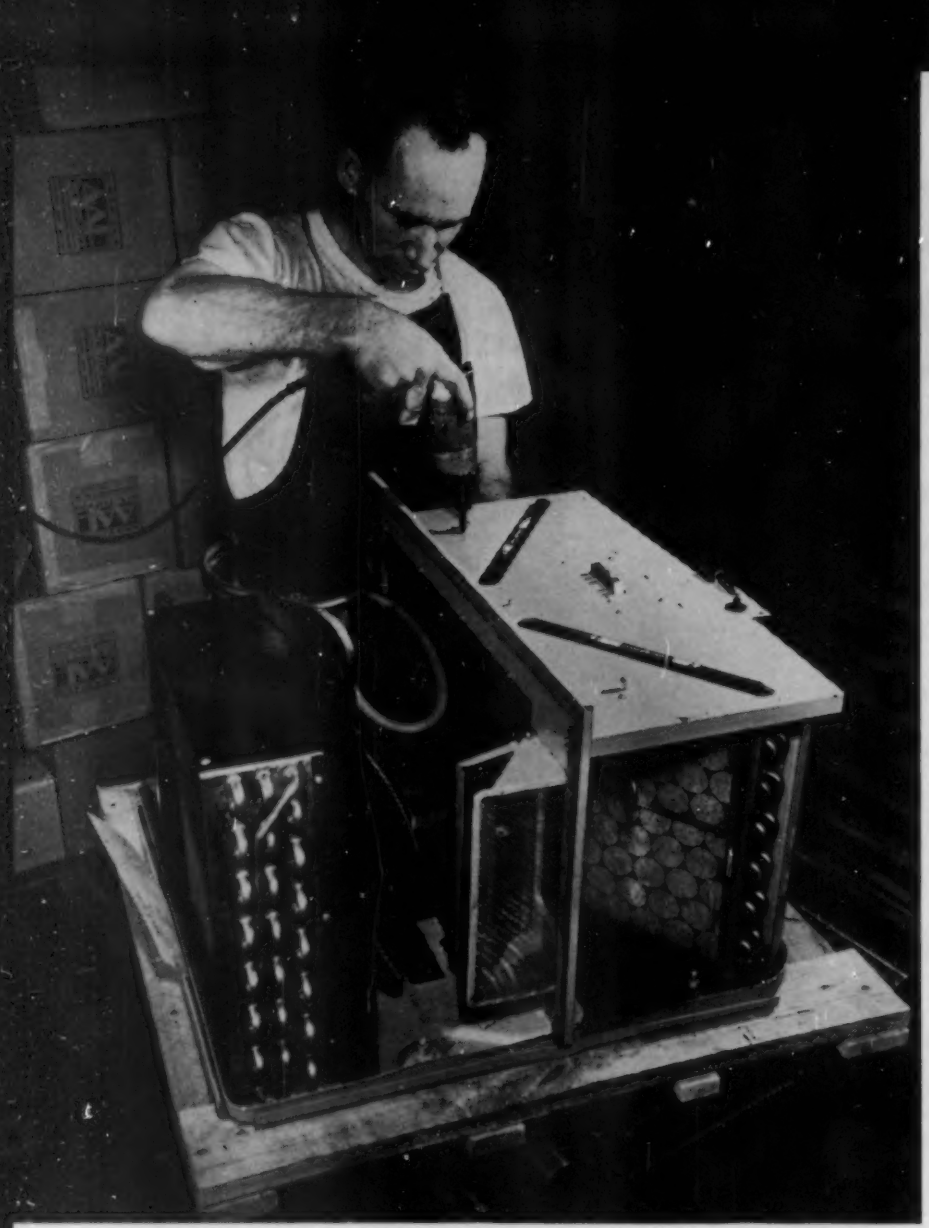
Whatever your fastening problem, there's probably a B. F. Goodrich Rivnut that can cut both assembly time and costs. Get complete information and engineering help by calling in a B. F. Goodrich Rivnut engineer. *The B. F. Goodrich Company, Department PE-45, Akron, Ohio.*

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO *and* fasten WITH. Explains construction, simplicity of operation . . . Write for your free copy today to The B. F. Goodrich Company, Department PE-45, Akron, Ohio.

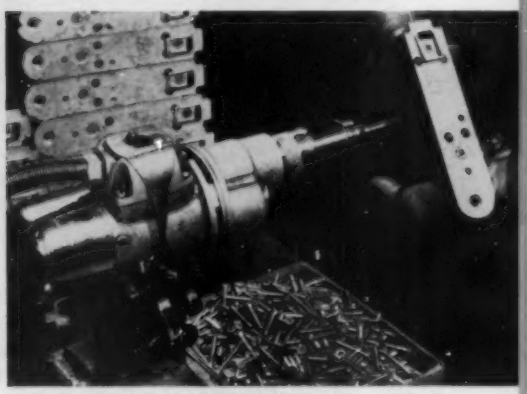
B.F.Goodrich RIVNUT

The only one-piece blind rivet with threads



TEN IN THE TOP. 10 Phillips self-tapping screws hold top panel to the frame of the Fedders ¾ ton room air-conditioner. "We found employees on the assembly line are the best salesmen for Phillips screws," says the assistant plant manager. "Rapid driving of the screws is important to them because they are on piecework."

STEADY ON THE STABILIZER. Here is the final assembly of the top cover of a horizontal stabilizer at Republic Aviation. The purchasing agent said, "You can really foul it up with one of those speed guns if it slips out of the screw slot, but the Phillips type head helps to prevent slipping. It holds on to the driver bit much better than the old-type screw."



5,000 WINDOWS in U.N. Building, New York City, have Caldwell clock spring sash balances. "We depend on the worker's adjustment of the Phillips head screw to make the balance function perfectly," says Caldwell's production manager. "We now use two sizes of Phillips recessed-head screws . . . and have speeded assembly. Our power drivers are mounted horizontally, since we discovered the units are easier to move around than the drivers."

NEW DISCOVERIES IN ASSEMBLY

Many manufacturers in many fields are finding Phillips Cross-Recessed-Head Screws lead to better methods and results

Allmetal Screw Products Company, Inc. • American Screw Company • Atlantic Screw Works, Inc. • The Blake & Johnson Co. • Central Screw Company • Continental Screw Company • The Eagle Lock Company • Elco Tool and Screw Corporation • Great Lakes Screw Corporation • The H. M. Harper Co. • The Lamson & Sessions Company National Lock Company • The National Screw & Manufacturing Co. • Parker-Kalon Div. General American Transportation Corporation • Pheoll Manufacturing Company Rockford Screw Products Company • Scovill Manufacturing Company • Shakeproof Division Illinois Tool Works • The Southington Hardware Manufacturing Company Sterling Bolt Company • Universal Screw Company • Wales-Beech Corporation

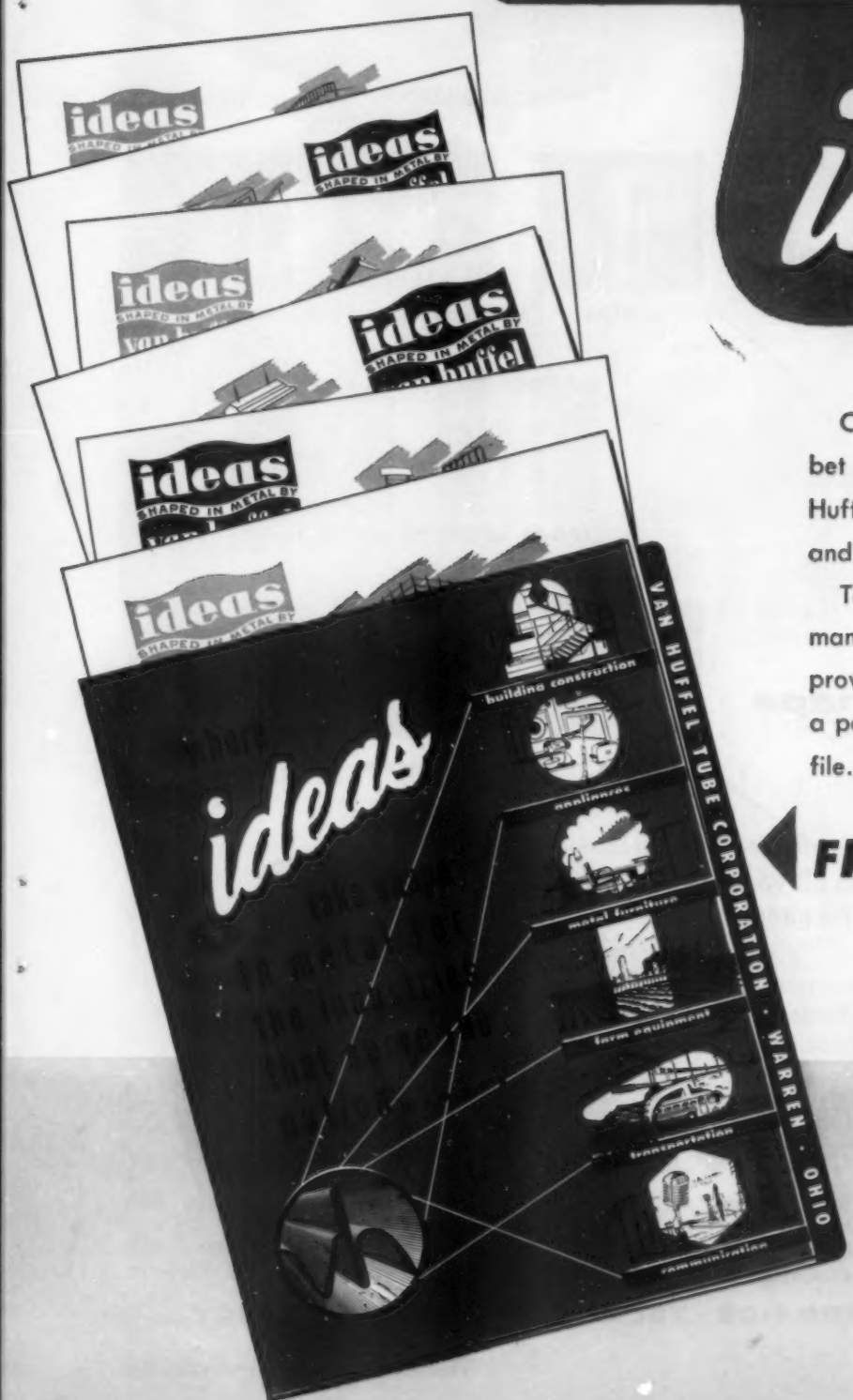
MANUFACTURERS OF PHILLIPS CROSS-RECESSED-HEAD SCREWS

THE FASTENERS OF TODAY ... AND OF THE FUTURE

X marks the spot

... the mark of extra quality

looking for building construction ideas?



Could be you are overlooking a good bet if you aren't familiar with what Van Huffel can do in cold forming metal shapes and tubing.

To give you a better picture of how other manufacturers are cutting costs and improving their products, we have prepared a portfolio of ideas that should be in your file. It's yours free for the asking.

FREE FOR YOUR FILES

VAN HUFFEL TUBE COPORATION BC-34
WARREN, OHIO

Please send me the BUILDING CONSTRUCTION idea portfolio

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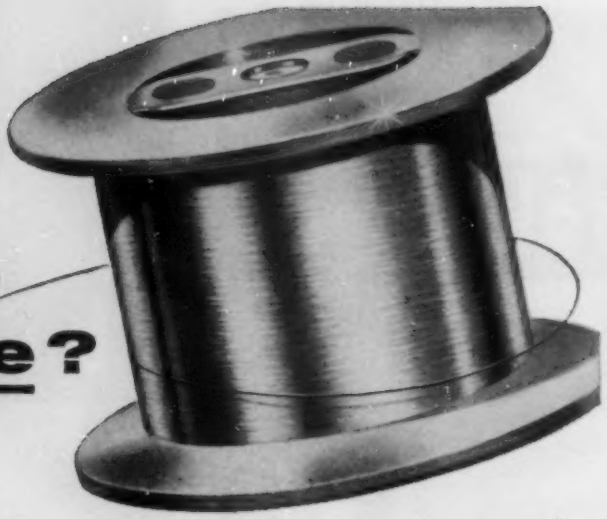
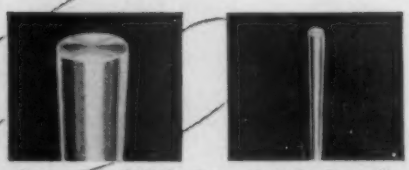
is there a Special way you want to use cold-drawn Wire?

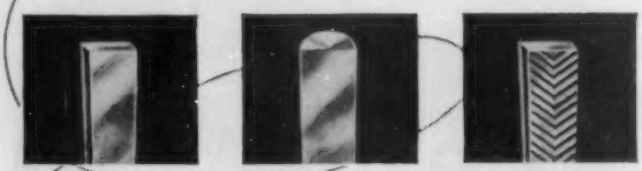


. . . if it calls for a special material

. . . in a special size



. . . or a special shape



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CHALLENGING to industry . . . the combination of remarkable properties offered by Du Pont MYLAR*

Here's a plastic film that can "take it"! But the exceptional strength of new Du Pont "Mylar" polyester film is only one of the remarkable properties that you can use to improve a product.

- Is space reduction important to your product? The thinness of tough Du Pont "Mylar" may permit you to design smaller equipment.
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- Need more efficient insulation? "Mylar" has exceptional dielectric strength.
- This versatile film can also be slit into yarn; it can be metalized; it can be bonded to other materials to make durable protective and decorative laminates.

It will pay you to find out more about the properties of "Mylar," and the amazing variety of fields in which "Mylar" is improving products, cutting costs. Mail the coupon for your copy of a new booklet that gives you the facts and figures. It may well suggest ways for you to profit from this new resource of industry. Write: E. I. du Pont de Nemours & Co. (Inc.), Film Department, Wilmington 98, Delaware.

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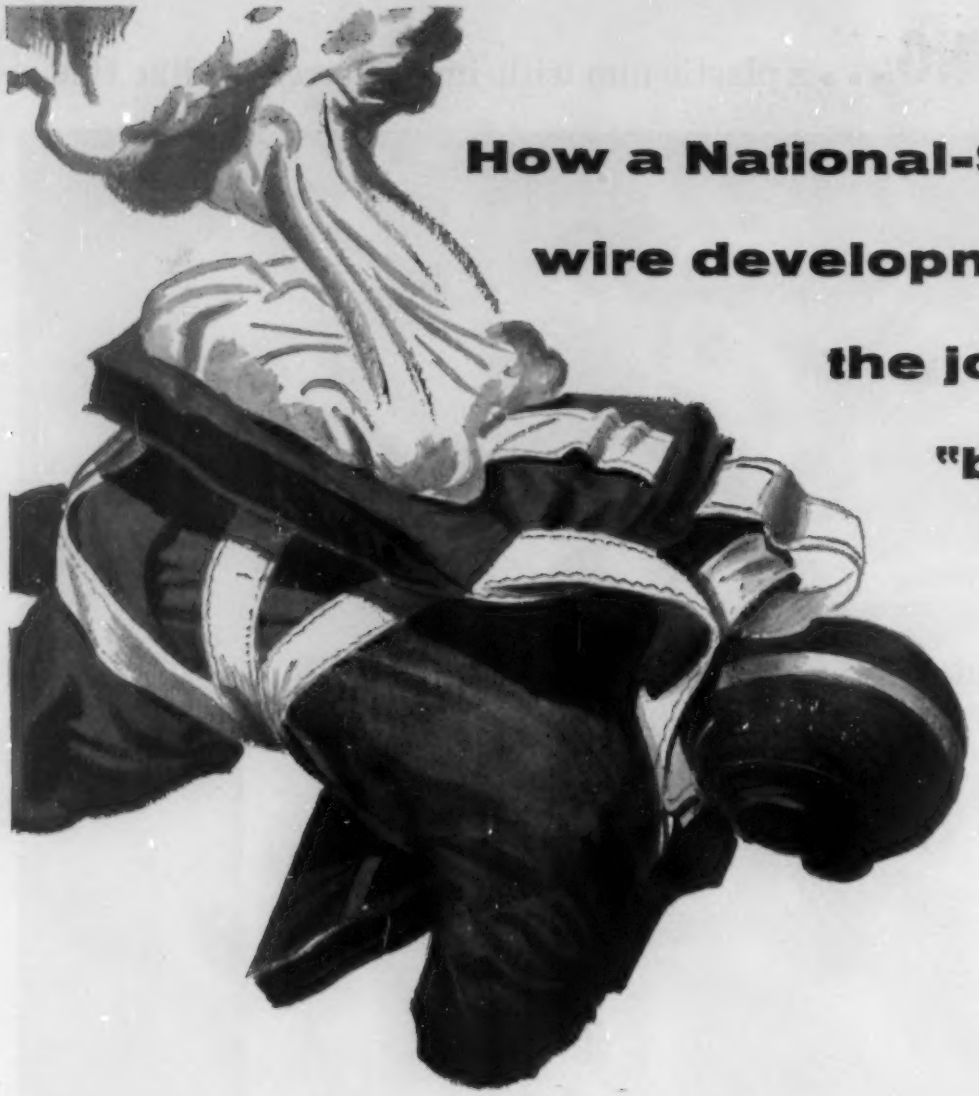

How a National-Standard wire development took the jolts out of "bail-outs"

● Until recently, when a pilot "hit the silk", the shock was almost more than his frame could absorb. A better parachute harness was needed.

A leading spring maker brought this problem to National-Standard.

Our engineers came up with a special stainless steel wire that would take the severe forming stresses created in coiling long, thin springs. In addition, this wire could be made into springs with unusual resistance to permanent set. And, finally, this wire enabled the spring designer to create a spring with high initial tension . . . a sort of delayed action characteristic which prevented the spring from opening until the severe shock of deceleration was applied.

We solved this problem by staying with it long after most wire and steel makers would have given up. It is this stay-with-it approach that has enabled National-Standard to solve more of the fussy problems in steel and wire making than anyone else in the industry.

If you have a need for steel or wire with unusual or even "impossible" characteristics, check first with National-Standard. We may already be making such products. And, if we don't know how to make it now, we'll learn.

NS NATIONAL-STANDARD Company MILES, MICHIGAN

NATIONAL-STANDARD COMPANY • NILES, MICHIGAN
Tire Wire, Stainless, Fabricated Braids and Tape

ATHENIA STEEL DIVISION • CLIFTON, N. J.
Flat, High Carbon, Cold Rolled Spring Steel

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Special Machinery for Metal Decorating

WORCESTER WIRE WORKS DIVISION • WORCESTER, MASS.
Round and Shaped Steel Wire, Small Sizes

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 15

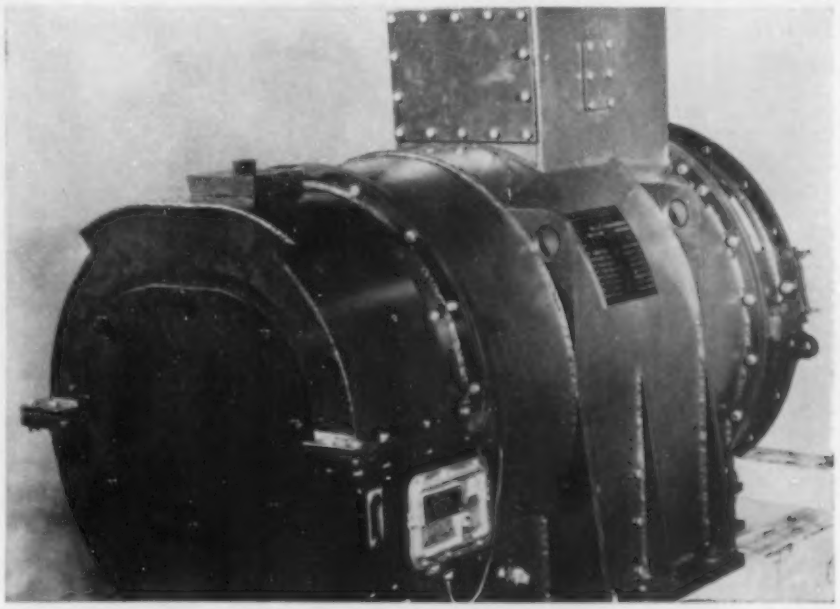
SILICONE EMULSION REDUCES WELL PUMP VALVE FAILURES

The water well valves manufactured by Stratoflo Products, Inc. of Fort Wayne used to go out of commission occasionally when the rubber poppet refused to free itself from the brass seat. Mineral deposits from certain kinds of water built up on the poppet, and cemented the valve shut.

The water supply would promptly fail and frequently the pump itself was damaged. Customer dissatisfaction was created, especially since the valve system is sometimes installed 100 feet or more underground and failure meant pulling the entire system out for repairs.

Stratoflo talked the problem over with their supplier, Goshen Rubber Co., Inc., and arrangements were made early in 1954 for dipping the rubber poppets, soon after they were molded, in a solution of 1 part Dow Corning 35B Emulsion to 15 parts water.

Failures stopped immediately. According to Stratoflo, "since using silicone-treated poppets, our testers have not discovered a single case of failure in the field due to sticking of the poppet." *No. 147*



NEW SILICONE INSULATED HIGH SPEED GENERATOR TOPS PREVIOUS POWER PER POUND RATIO BY 300%

Designed to service aircraft aboard ship, the new 400 cycle, Class H generator built by Westinghouse is rated at 600 kw at 12,000 rpm; weighs only 2100 pounds compared with 7500 pounds for a comparable machine of conventional design. The rotor of this new 4-pole unit measures only 9½ inches in diameter.

This 300% increase in power per pound ratio was accomplished by skillful design, high speed operation and the use of Silicone insulating materials with a conservative AIEE hottest spot temperature rating of 180 C. Built for rugged shipboard service the generator will withstand an impact shock in the order of 20 "G's" in the direction of the shaft and 10 "G's" across the shaft. It was first used aboard the U.S.S. Timmerman.

That's another example of how the extraordinary stability of insulating materials made with Dow Corning silicones is being employed to accomplish radical improvements in the performance and capacity of electric machines. If you are designing electric machines, you can forget the old limitations imposed by the relative instability of organic varnishes and insulating materials. If you are designing new electrically energized machines, you can't afford to settle for heavy, old fashioned electrical components with limited reliability. For more data write for Reference *No. 149*.

Excellent Design Plus Silicones Builds Business For Transit Maker

Although they built their first unit only a year ago, the Brunson Instrument Co. of Kansas City, Mo., is already the second largest producer of surveyor's transits in the world. One reason: the Brunson is the only transit on the market which is completely mounted on ball bearings. Another reason: the bearings, accurate to within 5-millionths of an inch, are all permanently lubricated with Dow Corning 33 Grease. The instrument is therefore designed to meet the requirements of Federal Specification GG-T-621A, including operation at —80 to 160 F. Thousands of Brunson transits are already in Government service in the Arctic. *No. 148*

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . .

Liquid Springs and shock absorbers, subject to constant recycling, have a modern design potential in a new silicone fluid, compressible up to 12% at 20,000 psi. Recently published data sheet provides detailed property information and outlines advantages of using Dow Corning F-4029 Fluid. *No. 152*

Temperature stable pressure sensitive silicone adhesives that stick to almost any material, can be applied and retain useful bond strength at temperatures from —100 to 500 F. Uses include bonding silicone treated electrical insulating materials and as a temporary bond to facilitate assembly of small parts prior to mechanical installation. *No. 153*

PAINT AND VARNISH PRODUCTION recently carried a short concise article describing the different types of silicone based protective coatings now available. Also included illustrations and information on several recent applications for these heat-resistant finishes. To obtain a reprint request *No. 154*

Parting Agent in shell process of metal casting, Dow Corning F-496 is a solvent solution of high viscosity silicone fluid that is effective and easy to use. A single application gives easy release of several resin-sand shells, and leaves no carbonaceous build-up. *No. 155*

Uprating of motor performance characteristics. The factors that must be considered in uprating motors by rewinding with silicone (Class H) insulation are summarized in the reprint "Uprating Horsepower with Silicone Insulation". Several case histories describe how industrial motors have been successfully uprated to deliver 50 to 75% more horsepower. *No. 156*

Silicone products most widely used, are indexed by type of application, in the 1955 Reference Guide to Dow Corning Silicone Products. A brief but comprehensive 8-page summary is given of the properties and applications. With increasing effort devoted to product improvement and cost reduction, such a reference guide to this remarkably stable group of engineering materials becomes increasingly important to design, production and maintenance engineers. *No. 157*

RTV SILASTIC PROTECTS AUTOPILOT IN BELL HSL-1 NAVY HELICOPTER

Electrical components in the autopilot system of the new HSL-1 tandem-rotor anti-submarine helicopter built by Bell Aircraft are encapsulated in Room Temperature Vulcanizing Silastic.

Why was RTV specified? Here's what Bell engineers say:

"The decision to provide a protective coating was based on the stringent environmental and test conditions, including sand and dust, high humidity, salt spray and wide temperature variations, to which the autopilot was subjected.

"Of the many coatings tested, only the silicone compounds provided adequate protection. They withstood extreme temperatures without embrittlement or softening. They exhibited low water absorption, and they have good thermal conductivity so that the heat transfer characteristics of coated components are not adversely affected.

"However, in most silicone rubbers, these optimum qualities are realized only after a controlled cure at elevated temperatures—temperatures higher than certain other autopilot components can withstand.

"This disadvantage was eliminated with the advent of Dow Corning RTV Silastic. RTV can be applied and cured under room temperature conditions or even in the field. Valuable time is saved and no extra equipment is needed either to apply initially or to repair this protective coating." *No. 150*

Silicone Molding Compound Qualifies For Guided Missile Service At 750

Light weight, high mechanical strength, good dielectric properties and excellent heat resistance motivate the use of a terminal block molded of Dow Corning 301 Molding Compound with brass inserts in an induction potentiometer produced by American Electronics of Culver City, California. Designed for aircraft and guided missile service, the unit is built to operate in ambient temperatures as high as 750 F.

To qualify for the job, the molded parts withstood five room temperature shock tests at 50 "G's" plus constant vibration in the order of 25 "G's" for 4 hours at 600 F.

Finally, the potentiometer was subjected to 1050 F for 15 minutes. The terminal blocks molded of Dow Corning 301 Molding Compound were shrunken and charred, but the brass inserts were still firmly retained. *No. 151*

Dow Corning Corporation, Dept. 8604, Midland, Michigan

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SILICONE NEWS is published for product design and development engineers by

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The Shaft Shows the Holding Power of ALLENPOINT Set Screws

ALLENPOINT—Smooth, even bearing surface. Deep point penetration for maximum holding power.

SERRATED POINT—Shaft penetration is slight and irregular. Bearing surface is spotty and rough.

Loosen a Set Screw and Look at the Shaft It's Pressing Against.

Has The Set Screw Made A Full Circle Impression?

To obtain the maximum resistance to rotation and sliding movement, a set screw must bear evenly on the shaft. Allenpoint Set Screws reproduce a full circle pattern against their mating surface for increased holding power. Even on shafts of small diameter you get a full circle impression with the smaller cup point of Allenpoint Set Screws.

Has The Point Left An Uneven Ridge Around The Indentation?

The holding power of a set screw will be greatly reduced if the bearing surface is rough and irregular. Serrated point set screws cut into the shaft, raising a chip, removing stock and weakening their grip. Allenpoint Set Screws press firmly into the shaft and form a smooth, deep indentation. The result is holding power that tops any other type point.

WHEN ORDERING THROUGH YOUR LOCAL INDUSTRIAL DISTRIBUTOR, SPECIFY ALLENPOINT SET SCREWS

For additional information contact your Allen Distributor or write to —

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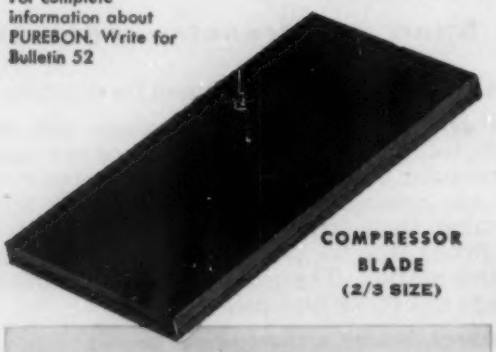
. . . the solution to your Lubrication problem is here . . . PUREBON

Carbon-graphite especially designed for mechanical applications.

For complete information about PUREBON. Write for Bulletin 52



Purebon is the designer's solution to many knotty problems involving sliding or rotating parts where lubrication is difficult and sometimes impossible. Purebon parts are molded or machined exactly to our customers' specifications here in our own plant, under our close supervision and inspection. *Because of the diversified characteristics of Purebon, applications are limited only by the designer's imagination.* If you have a problem involving insufficient lubrication at critical points of friction, our design engineering department will be happy to work with you toward its swift and successful solution.

PUREBON'S PROPERTIES

1 ***MOLDED TO SIZE—FOR MANY APPLICATIONS***
Tolerances of approximately 1½% of dimension required for molding most shapes.

2 ***SELF-LUBRICATING—OR BY THE MATERIAL HANDLED***
Varies with grade of Purebon.

3 ***STRONG AND TOUGH***
Transverse strength varies from 4,000 to 13,000 lb./sq. in. according to grade.

4 ***READILY MACHINABLE***
Tolerances as close as .0005 can be maintained where required.

5 ***CHEMICALLY INERT—NON-TOXIC***
Resistant to attack by chemicals of all kinds, used in food handling and processing equipment.

6 ***HIGH TEMPERATURE APPLICATION***
Most Purebon grades will operate efficiently in temperatures up to 700°F in air or much higher in neutral or reducing atmosphere.

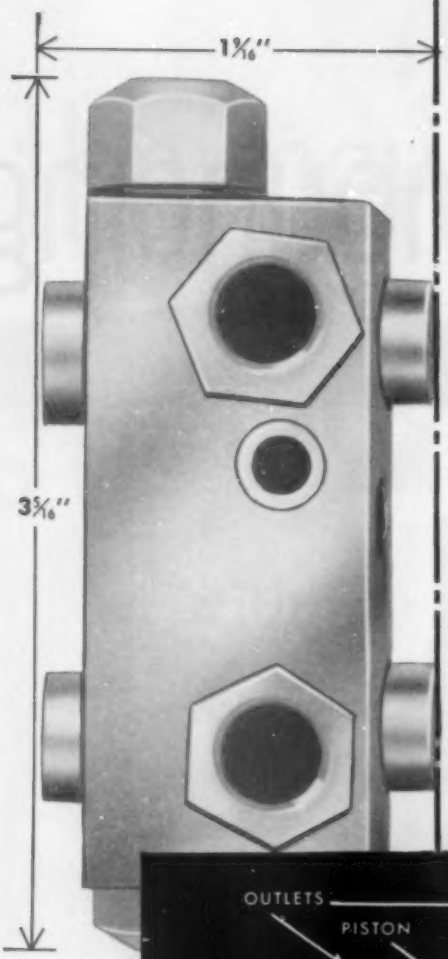
Leaders for over 40 YEARS in PURE CARBON PRODUCTS

PURE CARBON CO., INC.
448 HALL AVENUE
ST. MARYS, PENNSYLVANIA

A "mechanical brain" safety checks lubrication!

ALEMITE Accumeter®

Assures automatic, foolproof lubrication under toughest conditions, on heaviest machines, indoors or out!

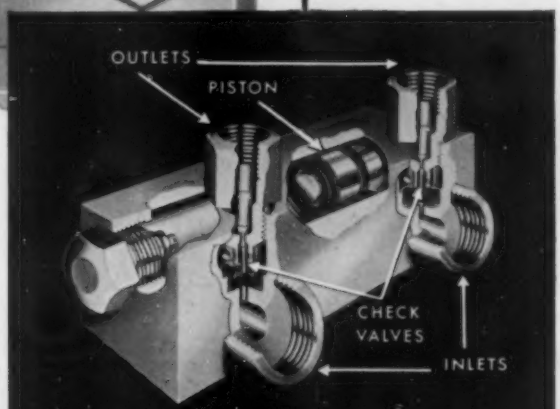


Imagine bearings operating under the very *worst* job conditions—in dust, rain, fumes, grit—even completely immersed. Now imagine what happens if you depend on ordinary manual methods of lubrication. Costly? Sure. Dependable? Hardly, may even be impossible.

That's the spot for Alemite Accumeter, the system with a control valve far more dependable than any man. The system that completely assures regular, proper lubrication, even under toughest conditions. Delivers the *exact* amount of lubricant where needed at the right time, *while the machine is in operation!*

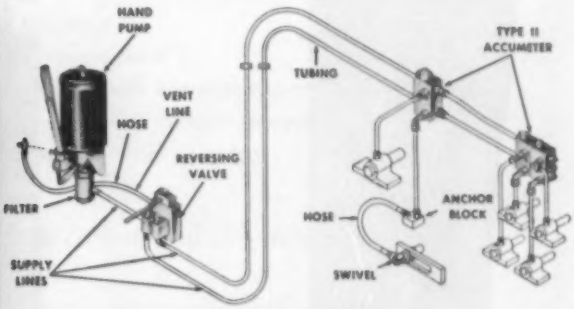
Costs, down-time, maintenance are all slashed by Accumeter—and output soars. That's why more than 95% of all major plants buying machine tools specify centralized lubrication!

And Alemite Accumeter Systems are easy to design into any machine. There is a system to solve any machine lubrication problem or combination of problems. See for yourself the tremendous operating advantages you offer when you specify automatic Alemite Accumeter.



Type II Accumeter Valves

Each serves two bearings. In four sizes delivering from .010 to .500 cubic inch of lubricant. Adjustable. Fully hydraulic—no springs. Completely sealed system serves up to 600 bearings. Manual or power operation.



Offers all these advantages!

- Eliminates shut-down time for lubrication. Adds productive time to machine output.
- Seals completely against dirt, grit, fumes, water all the way from "barrel to bearing."
- Prevents bearing troubles due to neglect or wrong lubricant.
- Services all bearings—including those inaccessible or dangerous—in one operation.
- Avoids work spoilage and bearing repairs due to over-lubrication.

Factory tested—field proved

Exhaustive, in-the-field tests show no appreciable variation in the amount of lubricant discharged after 73,312 lubrication cycles. Equal to 122 years of twice-a-day service!

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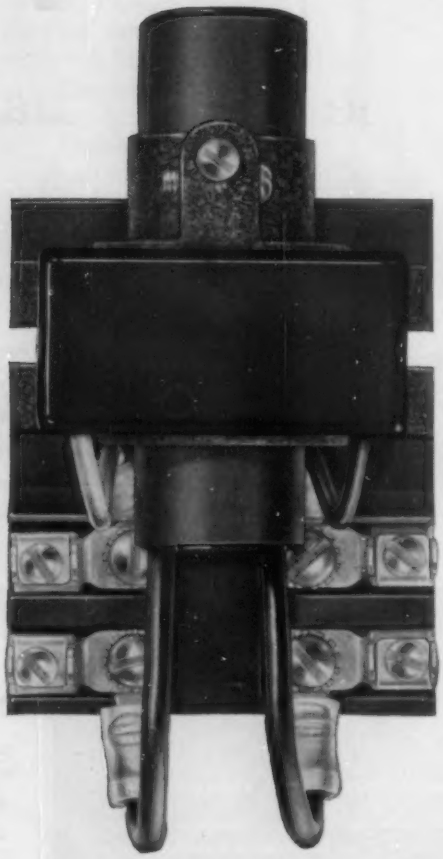


Like all Adlake relays, these new "Mighty Midget" relays require no maintenance whatever . . . are quiet and chatterless . . . free from explosion hazard. Dust, dirt, moisture and temperature changes can't affect their operation. Mercury-to-mercury contact gives ideal snap action, with no burning, pitting or sticking.

the new Adlake

"Mighty Midget"

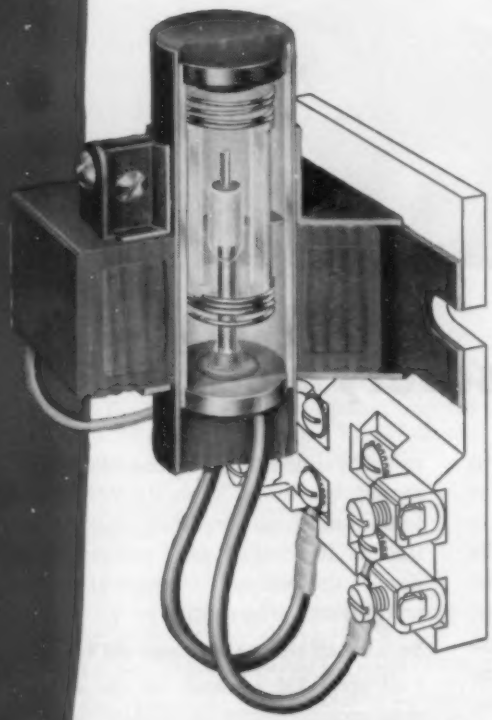
with the revolutionary **MOLDED** coil!

You expect the very latest from the company that originated the mercury plunger-type relays—and here *is* the very latest! It's the Adlake No. 1140, with molded coil in epoxy resin. That neat red coil is exclusive with Adlake, and gives these advantages:

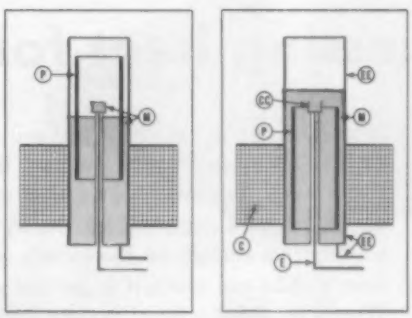
- **Better heat radiation**
- **Absolutely moisture proof**
- **Tested by 4 to 5 million operations at maximum capacity**
- **Guaranteed against coil failure—forever**

This new molded coil "Mighty Midget" is the newest reason why

it'll pay you to use Adlake mercury relays



This phantom view and operational sketches show the simple, dependable operating principle of the Adlake "Mighty Midget" Relay.



DE-ENERGIZED ENERGIZED

DE-ENERGIZED Plunger P is floating in mercury M. External circuit is open because main body of mercury M is below lip of ceramic cup CC.

ENERGIZED Coil C pulls plunger P down into mercury M. Mercury thus displaced completely covers ceramic cup CC filled with mercury. This establishes mercury-to-mercury contact between electrodes E and EE.

Adlake 98th year

THE Adams & Westlake COMPANY

Established 1857 • Elkhart, Indiana • New York • Chicago
the original and largest manufacturers of mercury plunger-type relays

Harnessing heat for safety's sake

3M ADHESIVES

A temperature of 215° F. is just too hot to handle, no matter where you find it. Yet today's wall-type room heater must operate at just such a temperature *inside*, while staying cool enough on the *outside* so that even a child can touch it in perfect safety. What's behind this bit of modern insulation magic? A 3M product called EC-226—the versatile adhesive you see in action above.

Applied quickly and easily by spray, EC-226 has "quick strength" . . . takes a gentle grip on the insulation immediately upon contact, simplifying the manufacturer's assembly operation. Then the adhesive dries to form a lasting bond that *keeps* the insulation at its cooling job—without a slip—despite the boiling-hot temperatures generated inside the heater.

See what adhesives can do for you . . .

Call upon 3M research for the solution to your specific design or production problem. Call an expert, your nearest 3M Field Engineer—or write for further information to 3M, Dept. 44, 417 Piquette, Detroit 2, Mich.

ADHESIVES AND COATINGS DIVISION **MINNESOTA MINING AND MANUFACTURING COMPANY**

417 PIQUETTE AVE., DETROIT 2, MICH. • GENERAL SALES OFFICES: ST. PAUL 6, MINN. • EXPORT: 99 PARK AVE., N.Y. 16, N.Y. • CANADA: P.O. BOX 757, LONDON, ONT.

MAKERS OF "SCOTCH" BRAND PRESSURE-SENSITIVE ADHESIVE TAPES • "SCOTCH" BRAND SOUND-RECORDING TAPE • "SCOTCHLITE" BRAND REFLECTIVE SHEETINGS • "3M" ABRASIVE PAPER AND CLOTH • "3M" ADHESIVES AND COATINGS • "3M" ROOFING GRANULES • "3M" CHEMICALS

"Old reliable" 21 in. sliding head floor drill stays accurate *with spindle on TIMKEN® bearings*

THE long-lasting precision of this Cincinnati 21″ sliding head floor drill has earned it the nickname "Old Reliable". One reason for this precision: the spindle is mounted on Timken® tapered roller bearings which are supported in an accurately ground and graduated quill. Two tapered roller bearings support the quill and two support the spindle pulley.

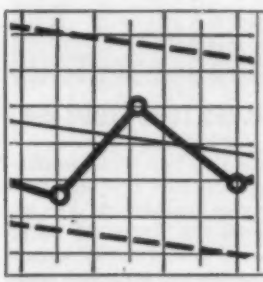
Timken precision bearings are especially designed for spindle applications. Run-out tolerances can be held to a maximum of 75 millionths of an inch. Due to their tapered construction, Timken bearings take both radial and thrust loads in any combinations, hold spindle rigid, permit pre-loading to any desired degree to prevent chatter.

Because of line contact between rollers and races, Timken bearings provide adequate capacity for any tool load. And spindle accuracy can always be maintained because Timken precision bearings are adjustable.

Timken bearings have contributed to the development of precision machine tools for over 25 years. To get longer life with minimum maintenance, buy or build machine tools that are Timken bearing equipped. Always look for the trade-mark "Timken" stamped on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

CINCINNATI LATHE & TOOL CO. uses Timken precision bearings on the spindle of its 21″ sliding head floor drill to insure long lasting spindle precision.



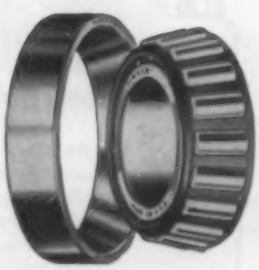
STATISTICAL QUALITY CONTROL

To insure uniform high quality and closer tolerances, the Timken Company uses statistical quality control. With it, tolerance deviations are plotted graphically. It's one of industry's newest, most scientific methods of improving product uniformity.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

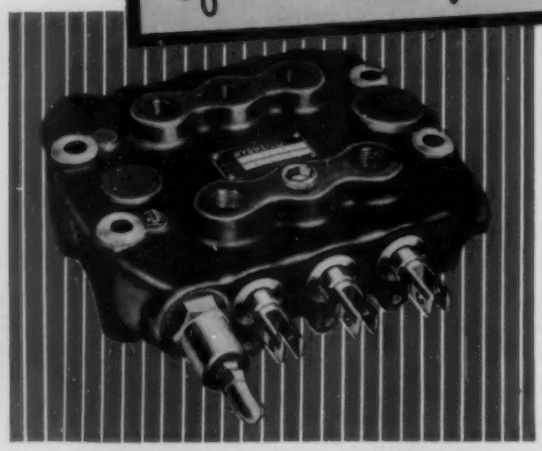
TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ⊂⊃ THE TIMKEN TAPERED ROLLER ⊂⊃ BEARING TAKES RADIAL ↕ AND THRUST →○← LOADS OR ANY COMBINATION ✳

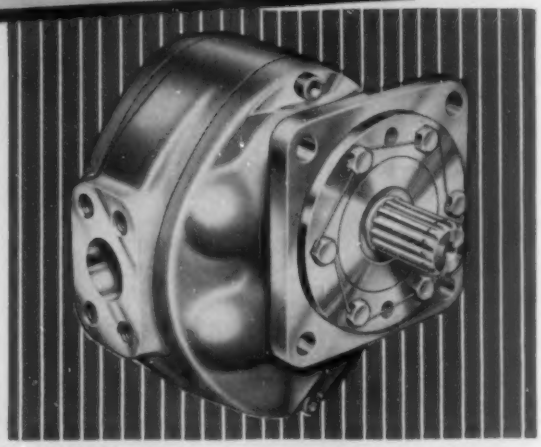
PUMPS
MOTORS
ENGINEER'G
VALVES
CYLINDERS

Mr. Hydraulics Engineer—
We suggest that you'll want to be familiar with these important developments in Fluid Power . . . products of The New York Air Brake Co.



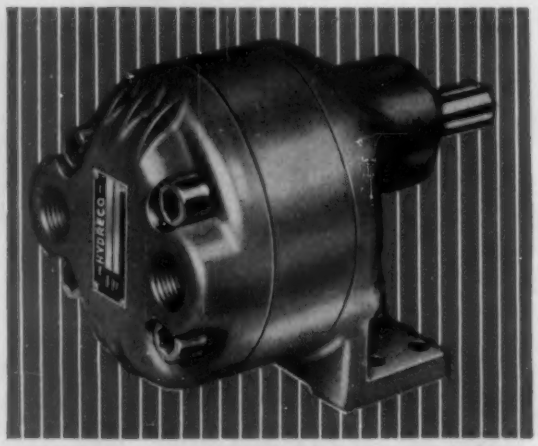
HYDRECO HOLLOW-PLUNGER CONTROL VALVES

The advancements made by HYDRECO engineering in multiple plunger, single and double acting control valves bring you new, accurate throttling . . . smooth, positive, fingertip control with notable freedom from binding, chattering or troublesome back pressures. Valves with 1 to 5 plungers in capacities from 5 to 80 gpm and operating pressures of 1500 and 2000 psi are now available for your present and projected equipment.



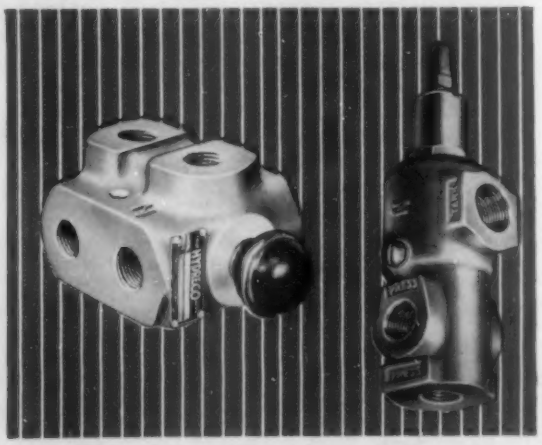
HYDRECO GEAR-TYPE PUMPS 1000/1500 psi

HYDRECO engineers have shattered the illusion that "any gear pump is just a gear pump". New developments in the famous HYDRECO Four-Bolt design provide higher pressures, higher speeds and higher efficiencies than were previously available. You'll want to know more about the many Heavy Duty features in HYDRECO Pumps. A full range of sizes — 3.3 to 55 gpm at 1200 rpm, 1000 psi.



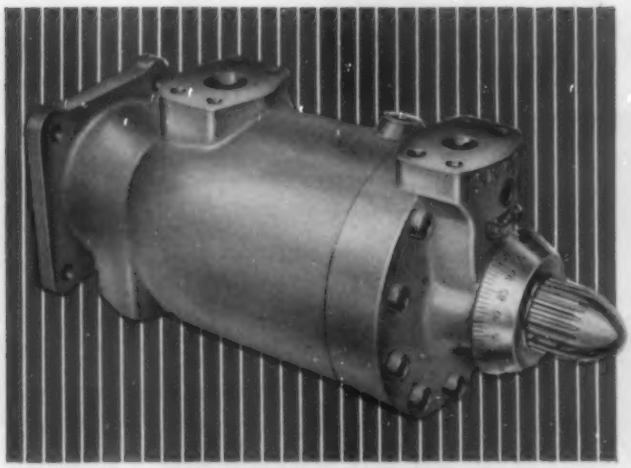
HYDRECO FLUID POWER MOTORS 1000 psi

For the many applications which call for reversible rotary motion with high starting and running torques...HYDRECO Four-Bolt, Gear-Type Fluid Motors are the economical and reliable answer. Precision, ruggedness and simplicity combine to ideally suit these motors to machine tools, oil drill rigs, conveyors, agitators and a thousand other uses. Sizes 3 to 17 hp at 2000 rpm, 1000 psi.



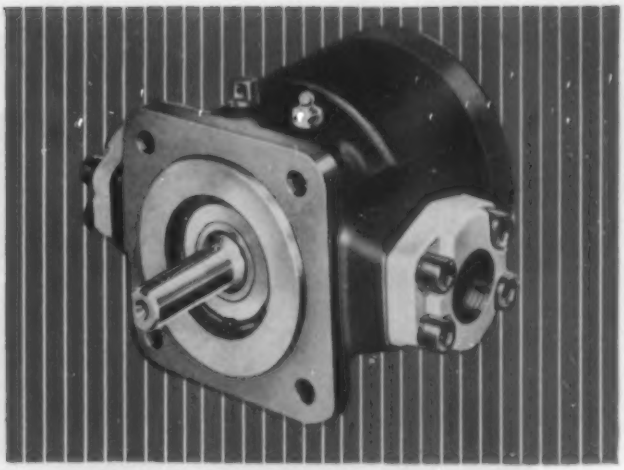
HYDRECO AUXILIARY VALVES 1000/2000 psi

HYDRECO engineers have made very important contributions to the modern hydraulic system in the Relief and Selector Valves now available for your applications. For accurate control over a long service life, HYDRECO Relief Valves in capacities to 80 gpm serve without chatter, squeal or whistle. The Selector Valves enable you to perform additional operations with your system, and these are available in capacities to 50 gpm.



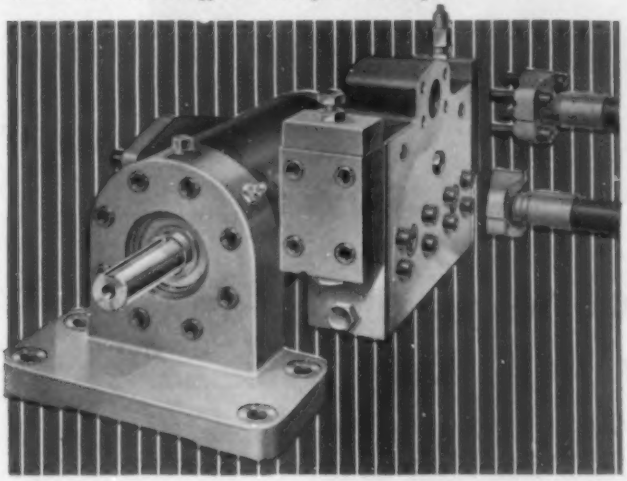
DUDCO VARIABLE DELIVERY PISTON PUMPS 5000 psi

The PV-600 Variable Delivery Pumps give designers a source of Fluid Power that is modern, compact, flexible, efficient and economical. These pumps are offered with two types of Variable Delivery Control. The handwheel Control provides accurate manual adjustment of delivery from zero flow to full flow. The Pressure Compensated Type features automatic pressure and flow control . . . delivery is reduced as pressure in the system reaches a pre-fixed maximum. Delivers 3 gpm at 5000 psi at 1200 rpm.



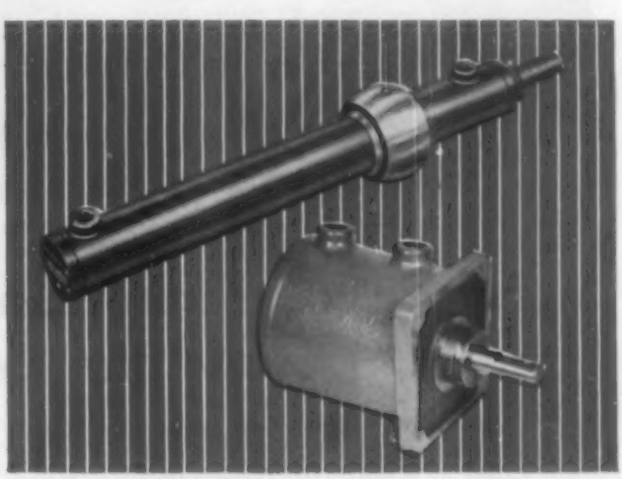
DUDCO DUAL-VANE HYDRAULIC PUMPS 2000 psi

Featuring a simplified, 3-unit construction, these DUDCO PF-100 Pumps provide designers with "a High Pressure Pump at a Low Pressure Price". The fully balanced DUAL-VANE construction assures high efficiency at higher pressures with wear reduced to an absolute minimum. Interchangeable Cam Rings add a factor of flexibility that conserves time and money. Available in flange and foot-mounted models, 3 to 11 gpm at 1200 rpm . . . 2000 psi.



DUDCO DOUBLE PUMPS WITH VALVE PANELS 2000 psi

These integral units meet the broad demands of circuits which call for substantial variation in pump volume, such as: "close and hold" or "traverse and feed" cycles. Hydraulic Presses, Plastic Molding Machines and many Machine Tools find these units highly efficient in operation, low in first cost, dollar-saving in reduced piping and valving in the circuit and supremely simple to service. Can be used in the operation of two separate systems or for Hi-Lo circuits.



HYDRECO CUSTOM-BUILT CYLINDERS

HYDRECO Hydraulic Cylinders enjoy an established reputation for quality and dependability. To achieve this degree of dependability entails craftsmanship and manufacturing niceties not practical in so-called standard cylinders built to meet a price. For engineers who seek performance, long-wear under heavy duty conditions and unmatched leakproof qualities, HYDRECO engineering and craftsmanship have something of special interest to offer.

Bring your Hydraulics Data up-to-date . . . Write for your FREE Bulletins TODAY!

THE NEW YORK AIR BRAKE COMPANY

1112 EAST 222nd STREET • CLEVELAND 17 • OHIO

INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

HYDRECO DIVISION
THE NEW YORK AIR BRAKE CO.
1112 East 222nd St., Cleveland, Ohio

Gentlemen:
Kindly send me catalog information on
HYDRECO Pumps ☐ Motors ☐ Valves ☐ Cylinders ☐
DUDCO 2000 psi Pumps ☐ 5000 psi Pumps ☐ Motors ☐
Pumps and Valve Panels ☐

Name_____

Address_____

City_____ Zone____ State_____

IN POWDER METALLURGY. . . IT'S AMPLEX

Pour Water and Gasoline in this Tank— and the Car Will Run!

The OILITE® permanent metal filter makes this gas tank different from that of most cars. Installed as standard equipment in all Chrysler-built cars since World War II, it not only prevents water from entering the fuel line but keeps out all foreign particles.

Army Ordnance tests demonstrated its effectiveness. Experimental installations were made in a number of Army trucks using—(1) standard tube fuel intake (with filter at carburetor end of fuel line) (2) floating filter (3) OILITE filter.

Two pints of ice crystals were put in the trucks' fuel tanks. Those with the standard tube failed to operate after 10 seconds. Trucks with floating filters stopped after 14 minutes, while those equipped with OILITE filters continued operating indefinitely without interruption, providing a steady flow of clean gasoline.

OILITE fuel filters are good for the life of the car. The filter allows ample flow even with 98% of the pores blocked. Tin plating prevents excessive gum deposits while the sloshing action in the tank keeps the surface clean.

OILITE permanent metal filters can help you in many ways. They are unusually successful for depth filtering, diffusing, metering, separating and flame arresting.

The engineering facilities of Amplex and Chrysler, unmatched in the powder metal industry, are ready to assist you. Call or write today for information.

CHRYSLER AMPLEX PRODUCTS

OILITE Bearings	Finished Machine Parts
Permanent Metal Filters	Friction Units

IT'S NEW! IT'S FREE!

First complete information on powder metal bearings, finished machine parts, filters and special parts. 48 pgs. Write for OILITE Engineering Manual E-55.

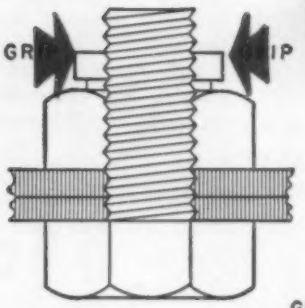
OILITE — *Only Chrysler makes OILITE*

CHRYSLER CORPORATION • AMPLEX DIVISION

Dept. F-4 Detroit 31, Michigan • Overseas Distribution—Chrysler Export

PROBLEM:
To effect a permanent nut and bolt fastening that will resist loosening under all conditions including severe vibration and temperature changes.

Solution: Lamson LOCK NUTS



U. S. PAT. NO. 2255286

Lamson Lock Nuts were designed for use where the going is rough and tough. Thus they are the ideal nuts for use where vibration is a factor . . . automotive equipment, construction machinery, railroad engines and cars and similar products.

Unlike many other lock nuts, the Lamson Lock Nut is a *one-piece all steel* nut that does not depend upon inserts or special methods of application for use.

As it is turned on the bolt, the heat-treated crown collar, slightly distorted from the round, grips the bolt firmly. When the nut is tightened the threads of the collar are forced against the "non-pressure flanks" of the bolt. Since the main body of the nut is exerting pressure on the "pressure flanks" a radial locking action results. Lamson Lock Nuts may be reused repeatedly without losing their locking action.

So, if you have a problem as stated above, consider Lamson Lock Nuts. They are the ideal solution from every standpoint.

Lamson & Sessions

The LAMSON & SESSIONS Co.
1971 West 85th St. • Cleveland 2, Ohio
Plants at Cleveland and Kent, Ohio • Birmingham • Chicago

The facilities of our company are at your disposal to assist you with any fastener problem.

Check the products below that interest you; tear off bottom of ad and send to us for complete information.

PLUG NUTS
Fasten metal parts efficiently from one side of the work.

PIPE PLUGS
Forged steel, heat-treated.

"1035" SET SCREWS
Cup point type, hardened and heat-treated.

PLACE BOLTS
With "Built-in" spring action for positive locking.

LAMSON LOCK NUTS
Economical, vibration proof. Can be used repeatedly.

LOK-THREAD PRODUCTS
For positive locking and sealing.

DIAMOND LOCK SCREWS
Plastic insert locks threads. Can be reused.

WELD NUTS
For strong, always level welding.

1

R & M Polyphase motor parts, consisting of rotor and stator, horizontal position. Light weight and reserve power for heavy duty use were the most important motor characteristics required.

2

This motor had to be lightweight, powerful and capable of running for long periods at 36,000 R.P.M. It's dynamically balanced with a diamond-turned commutator and specially anchored windings.

3

This powerful R & M Motor has a high starting torque for quick response; it runs cooler than normal, it's exceptionally quiet, and it's *compact*. Extra-heavily insulated, dynamically balanced, 100% inspected.

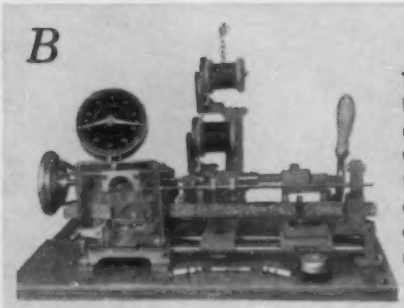
4

Variable speed was a must for this R & M Motor—to permit a wide selection of speeds without need for changing belts or pulleys. Motor is ¼ HP, AC-DC 5000 R.P.M., ball bearing equipped and open ventilated.

A

The ultra-high-speed SKIL Grinder, made by Skil Corporation, packs twice the power per pound of other grinders of similar weight. Tool and die makers say it's great!

B



The Geo. Stevens Model 125 Progressive Universal Winder made by Geo. Stevens Mfg. Co., Inc., world's largest manufacturer of coil-winding machines. One of a complete line of R & M Motor-equipped machines.

C

The powerful, easy-to-handle Buckeye Hi-Frequency Sander. It's ideal for automotive and industrial applications where tools are subjected to continuous, heavy duty service. R & M furnishes motors to Buckeye Tools Corporation in capacities from 3/16 to 4 HP.

D

The IBM Executive made by International Business Machines Corp., the only typewriter manufacturer exclusively producing electric machines. It's the mark of a modern office!

Can YOU match these motors to these tools and machines?

Here are some R & M fractional horsepower motors, and the machines for which they were selected or designed. Can you guess which goes with which? The answers are printed at the right . . . what was *your* score?

THE ANSWERS

R & M motors and motor parts, and the machines on which they are specified as standard, match up as follows:

1-C 2-A 3-D 4-B

ON COMPLETE MOTORS OR MOTOR PARTS . . .

Don't "guess" . . . let Robbins & Myers do a *scientific* job of matching the all-important motor to your product! Regardless of whether you need a motor that's standard or custom-designed . . . motors with special housing designs or motor parts to fit your housings, remember that R & M Motors are powering all types of equipment, such as . . . . . .

Portable Saws
Drills
Nut Setters
Hammers
Routers
Screw Drivers
Hedge Trimmers
Lawn Mowers
Nibblers
Lock Mortisers
Valve Grinders
Vacuum Cleaners
Files
Sanders
Pumps
Compressors
Hones
Business Machines
Cast Cutters
Food Mixers
Polishers
Planers
Portable Grinders
Sirens
Hair Driers
Advertising Devices
Ventilating Equipment
Oil Burners
Surgical Instruments
Grease Guns
Vibrators
Die Sinkers
Waxers

why you get better performance from a Fractional Horsepower Motor that's matched to your machine!

The most important single factor in the performance of any motor-driven product is the *motor itself*. That's why the engineers who designed the well-known tools and machines at the left came to Robbins & Myers to get the *right motor for the job*. Like many other R & M customers, they knew that the motor which met *every requirement*—one by one—was bound to improve the performance of their products, and *last longer* as well.

Selecting such a motor isn't simple. You can, of course, *look* at these examples, and try matching the motor to the machine for which it was designed. It's easy to guess, but in your business you can't afford guesswork.

Neither can we. That's why we've set up such systematic methods for designing motors. For example, we often use the R & M "Electrical Slide Rule." In this unique machine we first set up the electrical equivalents of motor *operating conditions;* then test equivalents of various motor *designs*. Result? Required motor characteristics can be calculated in minutes instead of days!

In some cases, the answers point to a standard motor. We have many such motors to choose from. But in other cases where special motors are indicated, we can do a fast, thorough, economical job of custom-designing a motor that's *exactly right* for your product.

In short, our experience—and our approach to your problem—isn't limited to standard motors we have "on the shelf."

If you feel that the motors you're now using aren't 100% right—in quality or in performance characteristics—we can make a real contribution to the solution of your problem. Use the coupon below . . . you will get the information you want promptly.

if it's an R&M it's the Right Motor!

ROBBINS & MYERS, INC.

SPRINGFIELD 99, OHIO • BRANTFORD, ONTARIO

ROBBINS & MYERS, INC., MOTOR DIVISION, PD
SPRINGFIELD 99, OHIO:

Please send me, without obligation, information on:

- ☐ Motor Parts for Portable Tools
- ☐ Universal Motors
- ☐ Capacitor Motors
- ☐ Universal and DC Motors
- ☐ R & M "All-Weather" Motors—up to 125 HP
- ☐ Please have a Motor Specialist call

Product we manufacture: _____

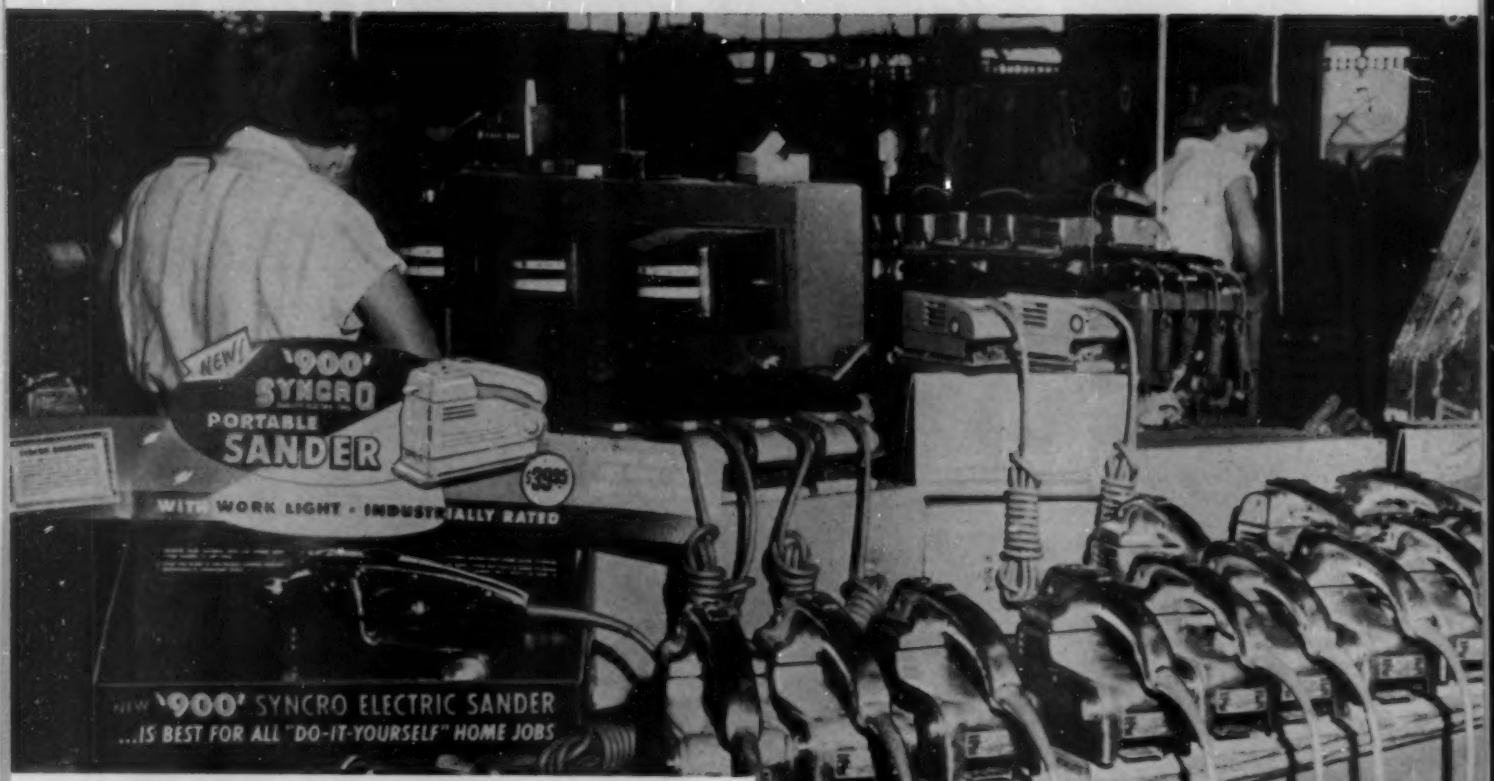
Name _____ *Title* _____

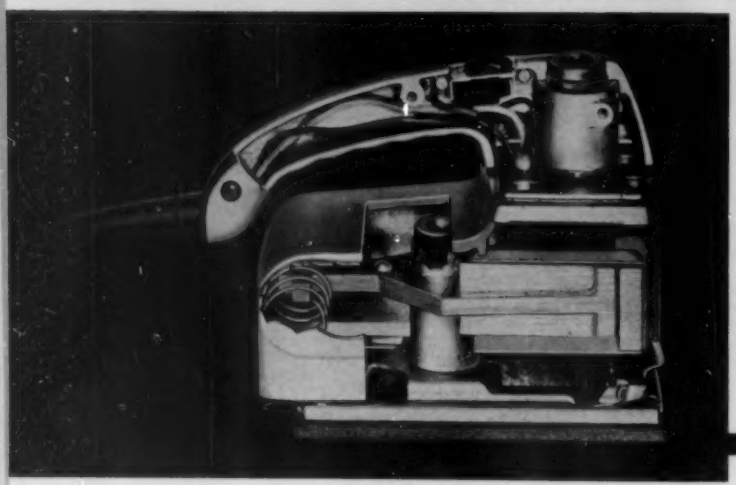
Company _____

Street _____

City & State _____

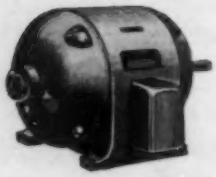
Here's why product designers





G-E MACHINE TOOL WIRE

Tough, strong, acid- and oil-resistant G-E Flamenol* machine tool wire is designed and manufactured to meet high operating standards under the severe conditions called for in machine tool wiring. Meets Joint Industry Conference Standards of National Machine Tool Builders Association.



G-E MAGNET WIRE

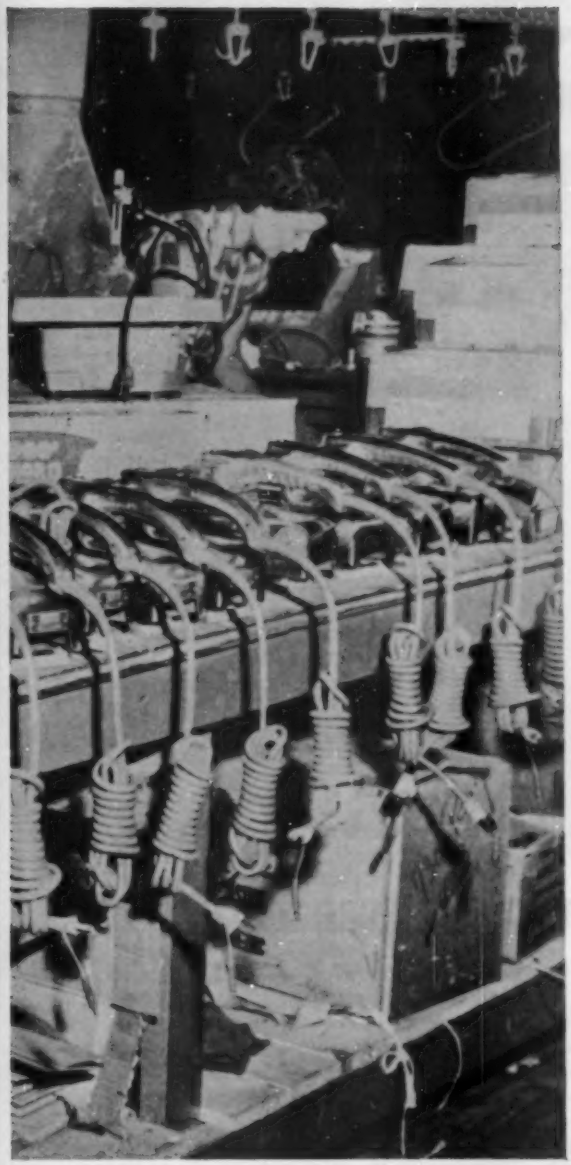
General Electric has the correct type for every requirement.

FOR CLASS A APPLICATIONS—(Temperatures up to 105 C)—Formex synthetic resin film-insulated wire.

FOR CLASS B APPLICATIONS (Temperatures up to 125 C) — General Electric Alkanex† magnet wire, Deltabeston* glass, or asbestos-insulated types.

FOR CLASS H APPLICATIONS (Temperatures up to 180 C)—General Electric glass or asbestos types impregnated with silicone varnishes, and Teflon** film-insulated magnet wire.

specify G-E wires and cords



These G-E products help keep manufacturer's rejects to one-tenth of one percent

Syncro 900 Sanders, products of Syncro Corporation, Oxford, Michigan, pass rigid factory inspection with a low rejection rate of only one-tenth of one percent . . . and Syncro engineers credit much of this performance to the G-E wires and cords they've specified as components in their sanders.

SJ TYPE CORDS — for long, dependable service despite hard usage. They're rubber-jacketed, lightweight, and flexible; resistant to acids, alkalies, and water.

FORMEX* MAGNET WIRE—for coil windings that stand up better than conventional-type enameled wire. More compact than those made of fibrous insulation.

The unusually low rejection rate allows the Syncro Sales Department to back up their dealers and customers with a "positive guarantee against motor burn-out, as long as the individual owns the tool."

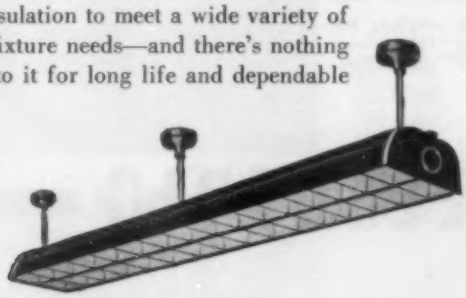
* Registered Trade-mark General Electric Company
† Trade-mark registration applied for by General Electric Company
** DuPont Trade-mark for tetrafluoroethylene resin

Progress Is Our Most Important Product

GENERAL ELECTRIC

G-E FIXTURE WIRE

General Electric fixture wire is available with asbestos, silicone rubber, or thermoplastic insulation to meet a wide variety of lighting fixture needs—and there's nothing superior to it for long life and dependable service.

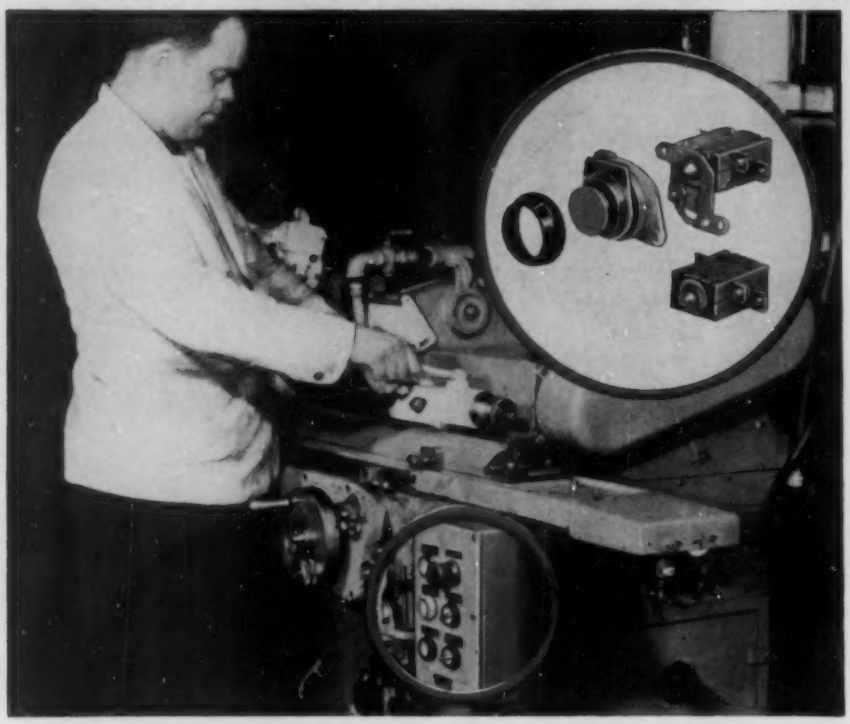


CAN G-E WIRES AND CORDS IMPROVE YOUR DESIGNS?

Investigate how G-E wires and cords can become an important part of your product story. Write today for your free copy of "G-E Wires, Cables, Cords for Product Designers." Address Section W155-467, General Electric Company, Bridgeport 2, Connecticut.

Designer's

G-E oiltight push-button line provides "building block" flexibility



You need to stock only 8 building-block forms—2 operators, 5 color coding rings and 1 contact block—to make 20 combinations. Building-block design adds up to new savings in assembly time, inventory costs and storage space. G-E oiltight push-button units are specifically designed to meet the demands of machinery designers and manufacturers, and include a variety of forms.

Indicating lights include resistor, transformer and full-voltage types, in six brilliant colors. Lights have faceted lenses which protrude from the mounting surface to assure visibility from any angle, yet are triple-sealed with oil-resistant, synthetic rubber.

Unit components, units, enclosures, or complete stations are available in this flexible line. Designed for appearance as well as efficiency, they lend a streamlined look to machines. Color rings stay bright. Both surface-mounted enclosures and flush-mounted plates meet JIC specifications.

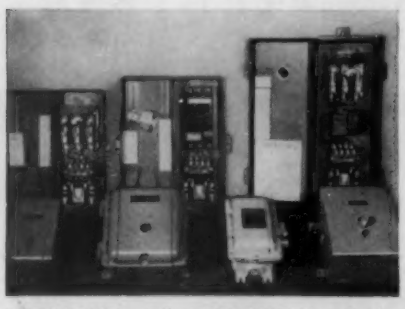
Specify G-E oiltight push buttons wherever hands or gloves may transfer oil or dirt. Ask for Bulletin GEA-5779B.

Quality G-E magnetic starters fit every machine design

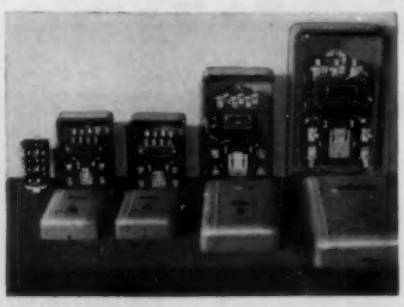
Why does it pay to standardize on G-E motor starters? Manufacturers themselves have given these reasons among many others: "Easiest to install." "Gives our customers the best buy in dependability." "Best long-term assurance we can give customers against motor burnouts."

Starting with the basic contactor unit, you can have accessories, interlocks, control transformers and relays to fit your specific needs. Installation is really simple—G-E starters are front-wired, with hardened panhead screws and plenty of room for easy manipulation. Clamp-type terminals are clearly identified. Knockouts are provided in top, sides and bottoms of enclosures. Screwdriver (all you ever need for wiring) goes straight in to all terminals. "Strongbox" coil construction means a slipping screwdriver won't damage the coil, because the coil is inside a tough, molded plastic case.

Additional benefits for your customers include; the permanent air gap that helps prevent contacts from "sticking in," bi-metallic overload relays that adjust easily for manual or automatic reset, sturdy all-around construction and good looks. For further information on the complete line of General Electric starters, see Bulletin GEA-6198.



THOUSANDS OF VARIATIONS of the above starters are available from the complete line of G-E magnetic motor starters.



Each General Electric starter employs the same basic contactor which has proved superior in severe industrial applications.

GENERAL ELECTRIC

Digest

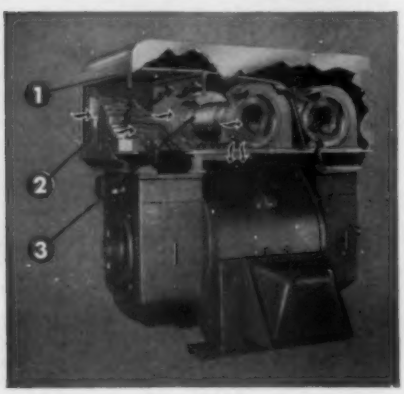
MOTOR & CONTROL HIGHLIGHTS

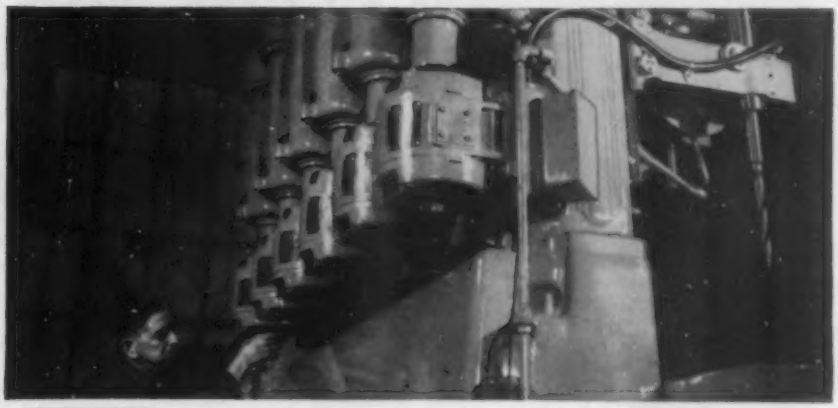
Unit-cooled d-c motors keep out dirt and dust

UNIT-COOLED MOTORS mount at any angle—shown here driving machine boring engine blocks.

If your machines must operate in environments which make open or partially enclosed motors difficult or expensive to maintain, G.E.'s unit-cooled d-c motor is an ideal solution. It is completely self-contained, with no external duct work or air filters to install.

The motor has two air flow systems: external (black arrows in cutaway photo below), and internal (red arrows). The compact, top-mounted cooling unit (1) is within the over-all dimensions of the main motor. Self-cleaning vertical plates (2) are smooth and need little maintenance. Two blowers (3) operating the double ventilation system are powered by separate motors. Available: standard ratings from 15 to 200 hp, in constant or adjustable-speed types. Bulletin GEA-6091 gives complete information.





TRI 55 CLAD motors now available in quantity thru 10 hp—samples to 20 hp

Now you can take advantage of increased availability of new G-E motors in re-rated NEMA frame sizes. When you design-in Tri/Clad '55' motors, your customer will have one of the most modern electrical drives available. This motor line includes standard polyphase and single-phase; NEMA "C" face and "D" flange end shields, brake, gear, shell type, three-quarter, wound-rotor, close-coupled pump motors and specials to your requirements.

Design advantages include weight reduction up to 33% and size up to 40% in some ratings. Note compact, modern appearance of Tri/Clad '55' motors being installed on radial drilling machine, above. Bulletin GEA-6200.

Smaller, more compact fhp motors mount easier

These G-E fractional-horsepower motors free you from previous design limitations, give your machines greater salability. Lighter weight lowers shipping and handling costs. Smaller size means space saved on driven machines, better use of valuable warehouse space. Improved appearance adds to your product's sales appeal. And all-angle operation means this standard, general-purpose motor can often replace costly specials. On the assembly line they're much easier to install, which means additional savings. For full information check Bulletin GEA-5567.

General Electric Co., Apparatus Sales Division, Sec. C668-120, Schenectady, N. Y.

Please send me the following bulletins:

√ for reference × for immediate project

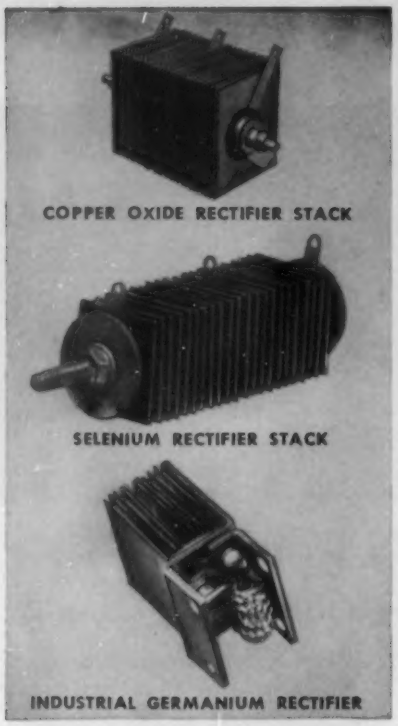
- ☐GEA-6198 Magnetic motor starters
- ☐GEA-5779B Oiltight push-button units
- ☐GEA-6091A Unit-cooled d-c motors
- ☐GEA-5567 Fractional-hp motor
- ☐GEA-6200 Tri/Clad '55' motors

CONSULT YOUR SWEET'S PRODUCT DESIGN FILE. You'll find everything electric for machinery manufacturers in the General Electric Section.

NAME..... COMPANY.....

CITY..... STATE.....

TURN PAGE FOR MORE G-E PRODUCT HIGHLIGHTS



G-E metallic rectifiers answer industry's growing d-c power needs

General Electric offers designers a complete line of copper-oxide, selenium, and germanium rectifiers to exactly meet specific d-c power requirements.

General Electric copper-oxide rectifiers are able to withstand momentary voltage or current overloads and have the longest life and highest efficiency of all rectifiers at six volts or under. General Electric selenium rectifiers, with their lower forward voltage drop and higher reverse resistance, have proved a very satisfactory source of direct-current power for magnetic clutches and brakes on machine tools. A new 45-volt selenium cell for industrial use provides 40,000 hours of life at 35 C ambient, with no derating at temperatures as high as 120 C. Economical, efficient germanium rectifiers have the best regulation of any metallic rectifier, in addition to the highest output voltage per cell, best current output, and lightest weight per watt output.

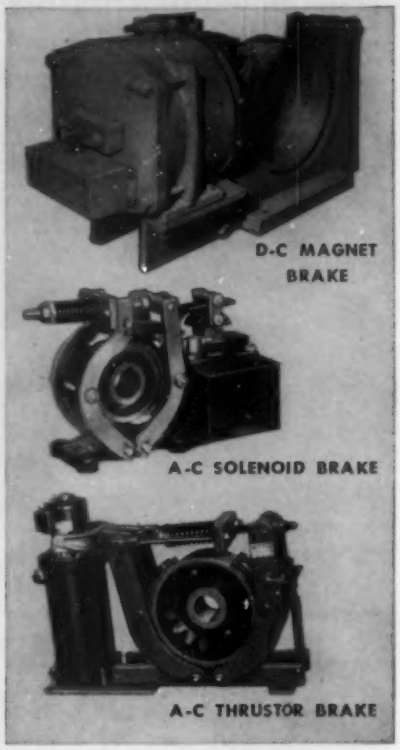
For information on characteristics and application, see Bulletins GEA-5699A (copper-oxide), GET-2350 (selenium), and GEA-5773 (germanium).

G-E a-c and d-c brakes install and adjust easily, give positive stops in varied machine applications

For every braking need, G.E. can provide brakes with all the features that mean quick, easy adjustment and reliable operation. For instance, G-E d-c magnet brakes require only a wrench to make the one simple adjustment to compensate for lining wear. In actual on-the-job tests, the two-shoe, single magnet brake has established high standards of performance in applications where continuity of service and low operating costs are of first importance. Design research was based on industry requirements and standards established by AISE.

G-E a-c brakes are spring-set, two-shoe holding brakes, electrically released by a solenoid in the smaller sizes and a thrustor in larger ratings. Three easily made adjustments control torque, wear, and clearance. They give smooth positive braking in either direction, and their long lining life and wheel life reduce maintenance costs. Both solenoid and thrustor types are available in open, dripproof, or watertight construction.

For further information, check coupon for Bulletin GEA-6214 (d-c brake) and GEA-1518B (a-c brakes).



G.E. announces new, smaller, low-cost tachometer generator

NEW D-C TACHOMETER GENERATOR
TWO MODELS AVAILABLE

50 volts d-c/1000 rpm	100 volts d-c/1000 rpm
0–500 rpm min.	0–500 rpm min.
0–5000 rpm max.	0–2500 rpm max.
Accuracy of ±1% of full scale	Accuracy of ±1% of full scale

Many speed-measurement and control problems in machine design can be answered at low cost with the newest in General Electric's line of d-c tachometer generators. It occupies a minimum of space and can be flange- or foot-mounted, installed horizontally or vertically. This high versatility allows the equipment to be direct coupled, geared, or belt driven, as needed. It is tapped for ½-inch conduit connections.

Two different models are available. The high output voltage of 100 volts per 1000 rpm is ideal for use as a pilot exciter on many control applications and for speed indication. A 50-volt model is also available for speeds up to 5000 rpm.

Whatever your voltage, speed, accuracy, or cost consideration, G.E. has the combination of tachometer generator and instrument to meet your requirements. Write for Bulletin GEC-1258.

GENERAL ELECTRIC

Designer's Digest

PRODUCT HIGHLIGHTS

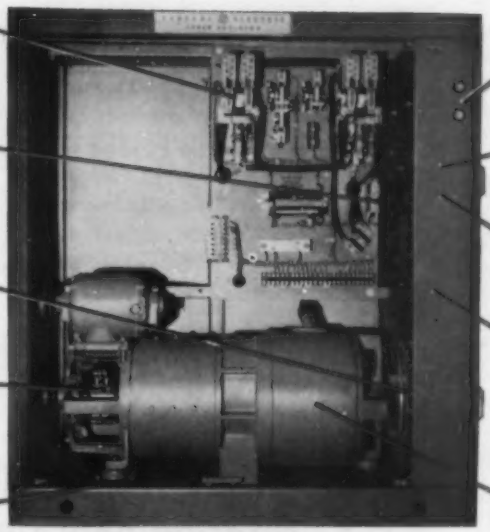
Full capacity d-c magnetic blowout contactors lengthen life of the contact tip.

Complete protection of d-c drive motor and motor-generator by a-c and d-c overload relays.

Shaft mounted fan keeps cabinet pressurized—helps keep dirt out.

Large openings in end shield allow easy inspection of brushes and commutator.

Self-supporting m-g set specially mounted to help prevent vibration.



Speed Variator power unit.

Simple, start-stop button.

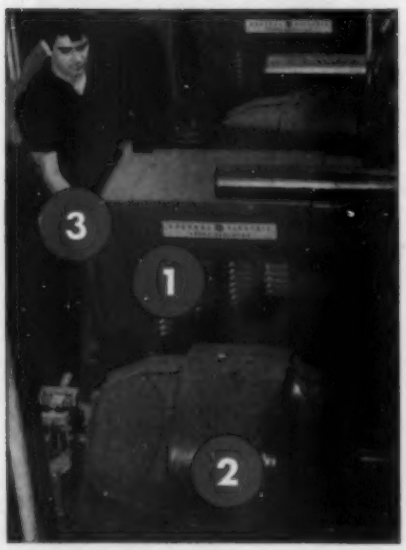
A-c undervoltage protection. Protection of a-c equipment by a-c overload relays.

A-c short circuit protection.

A-c control in isolated compartment.

Dependable, powerful motor-generator set matches overload capacity of the d-c drive motor.

For custom-engineered adjustable speed specify packaged G-E speed variators



BASIC SPEED VARIATOR consists of: (1) the power unit, designed to save space, (2) the d-c drive motor and (3) the operator's controls.

Before a G-E speed variator leaves the factory, it is pre-engineered, assembled, packaged and completely tested according to *your* specifications. This adjustable-voltage d-c drive means savings in lower installation cost and more efficient production. Simply set components in place—motor, power unit, control—and connect the power.

Speed variators are ideal for lathes, grinders, milling machines, broaches, slotters, boring mills, testing stands, conveyor systems—any machine requiring adjustable speed drives. Providing compensated speed regulation throughout load changes, the basic model covers a wide speed range. The power unit and operator's control can be located as near the driven machines as necessary. Control and regulator "building blocks," added to the basic unit, give even more versatile and accurate speed control, to fit your specific requirements. Bulletin GEA-6127.

General Electric Co., Apparatus Sales Division, Sec. C668-121, Schenectady, N. Y.

Please send me the following bulletins; ✓ for reference ✕ for immediate project

- ☐ GEA-6127 Speed Variators
- ☐ GEA-1518 A-C Brakes
- ☐ GEA-6214 D-C Brakes
- ☐ GEC-1258 D-C Tachometer Generators
- ☐ GEA-5699A Copper Oxide Rectifiers
- ☐ GET-2350 Selenium Rectifiers
- ☐ GEA-5773 Germanium Rectifiers

CONSULT YOUR SWEET'S PRODUCT DESIGN FILE. You'll find everything electric for machinery manufacturers in the General Electric Section.

NAME..... COMPANY.....

CITY..... STATE.....

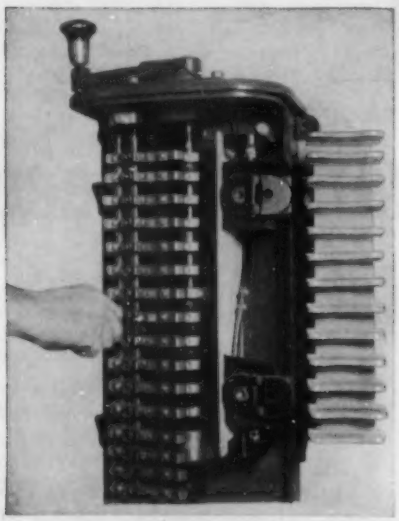
TURN PAGE FOR INDUSTRY CONTROL HIGHLIGHTS

General Electric drum switches offer you simplified installation and maintenance

FAST, EASY INSTALLATION and simplified maintenance are part of G.E.'s full line of drum switches for d-c motors and a-c applications of motor control. The conduit box is provided with knockouts in the bottom, back, and sides so that conduit connections can be made to suit any installation conditions.

EASILY REMOVABLE DRUM SWITCH FRONT COVERS (and back covers on larger units) provide plenty of elbow room for wiring and for adjustments. Installation and maintenance time is substantially reduced because of complete and free access to working parts.

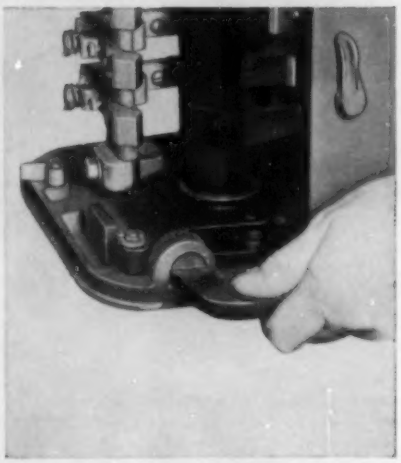
SIMPLE FINGER ADJUSTMENT is accomplished readily with only a screw driver as shown below.



CONTACT LIFE IS DOUBLED because the element is reversible. When the contact surface shows excessive wear merely reverse, and use the opposite side. This is easily accomplished by the removal of but one screw. Segments are easily replaceable and can often be turned end for end to provide even longer life.

PAWL SPRING ADJUSTMENT is simplified by its accessibility from the FRONT of the controller. Adjustments are made by turning a slotted screw as shown in the photograph (right). The arc chute assembly is conveniently hinged for complete access to the pawl spring as well as other internal parts of the switch.

OPERATING MECHANISM CAN BE POSITIONED in increments of 90° by relocating the stop piece on the main shaft. The standard horizontal handle is completely and simply interchangeable for rope wheel, vertical handle, or switchboard mechanism. This ease of interchangeability exists for all operating mechanisms and between various sizes. For additional information on drum switches see coupon on next page.



Complete terminal board accessibility with G-E rotating-cam-type limit switches

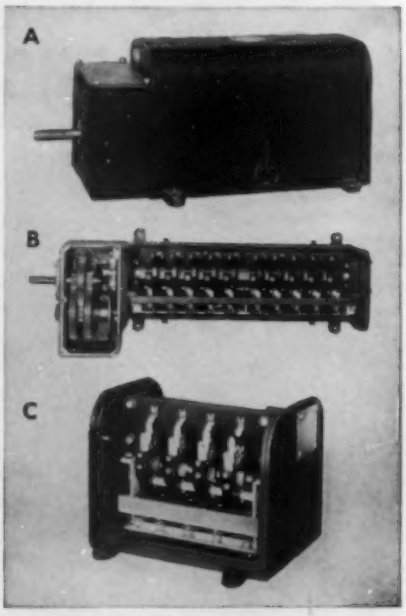
General Electric rotating-cam-type limit switches are built ***without shunts or drum-type segments*** allowing complete access to the terminal board. Adaptable for continuous rotation in either clockwise or counterclockwise direction and for reversing service they are available for two-, four-, six-, and ten-circuit installations.

BUILT FOR RUGGED DEPENDABILITY, G-E rotating-cam-type limit switches are made with cast-iron frames and sheet metal covers. The contacts are double-break type with silver tips. Better interrupting ability and precise operation are achieved by "snap" action. For additional information on G-E limit switches see coupon on opposite page.

A. IC9441-LS429 Geared Limit Switch with self-contained gear-reducing unit mounted on frame.

B. IC9441-LS437 rotating-cam-type limit switch with contacts provided for ten circuits.

C. IC9441-LS464 rotating-cam-type limit switch designed for four circuits.



GENERAL ELECTRIC

Designer's Digest

INDUSTRY CONTROL

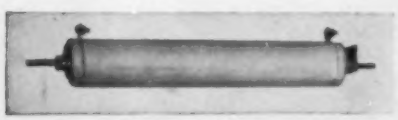
Complete line of G-E resistors gives you maximum application flexibility

DESIGNED WITH A WIDE RANGE of ohmic values and current capacities, G-E IC9033 resistor units are available in elements of similar appearance and construction. Any intermediate ohmic values or capacity desired are easily obtained by the use of taps or by connecting IC9033 resistors in series, series-parallel, or parallel.

MOUNTING PROBLEMS ARE SIMPLIFIED because the resistors have uniform mounting dimensions over a complete range of ratings. Designed to give you greater flexibility, the IC9033 is ideally suited for applications such as load banks where resistors must cover a wide range of ohmic values and current capacities.

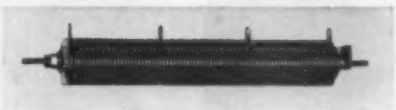
STURDY CONSTRUCTION of these resistors makes them particularly suitable for use on travelling cranes, portable equipment and other applications where vibration and sudden jolts are likely to be encountered.

FOUR FORMS OF THE IC9033 are available: smooth-wound, smooth-wound with variable slider, open-wound, and edgewound units. Each form has five sizes ranging from $6\frac{3}{8}$ to $18\frac{3}{8}$ inches, except Form F which is not made in the shortest length.



FORM A SMOOTH-WOUND UNITS are suitable for low current and high ohmic values.

Because the resistance wire on the Form A has uniform spacing achieved by tension winding, the unit has even heat distribution throughout, assuring the resistor of longer life. High mechanical strength is obtained through the use of a cylindrical core with a steel mounting rod extending through length of unit.



FORM B OPEN-WOUND UNITS are designed for higher current and lower ohmic values than the Form A units.

Short circuits between turns are virtually impossible in this unit. The core is cross-shaped with four projections having molded grooves which securely hold wire in place. The rugged porcelain body is further strengthened by a steel mounting rod extending through the unit's lengh.

FORM C EDGEWOUND UNITS are designed for 50 amperes maximum.

Alloy ribbon is employed as a resistor element in the Form C. It is helically wound, edgewise, and screwed to "I" shaped porcelain insulators with teeth and grooves in upper and lower edges. High heat dissipation is assured by extremely large surface areas offering very little ventilation restrictions. High current capacities are possible because of fewer turns per inch and large cross sectional areas.

FORM E SMOOTH-WOUND UNITS are the same as Form A but with a slider added.

FORM F EDGEWISE-WOUND UNITS range up to ratings of 96 amperes.

Like the Form C, this unit is wound around a one-piece porcelain core. Heavier ribbon is used to obtain higher ampere ratings.

Check These Features of G-E IC9033 Resistors

- √**Wide Range of Ohmic Values and Current Capacities.**
- √**Compact Design.**
- √**All Parts Corrosion-Resistant.**
- √**Low Resistance Welded Terminals.**
- √**Permanent Electrical Characteristics.**
- √**Shock Resistant Construction.**
- √**Connections Easily Made on Accessible Terminals.**
- √**Available with Mounting Feet, in Unit Boxes, and in Frames.**

For additional information on G-E IC9033 resistors see the coupon below.

General Electric Co., Apparatus Sales Division, Section C781-9, Schenectady 5, N. Y.

Please send me the following bulletins: for reference (x) for immediate project (√):

☐ **GEA-5994 LIMIT SWITCHES** ☐ **GEC-1302 DRUM SWITCHES**

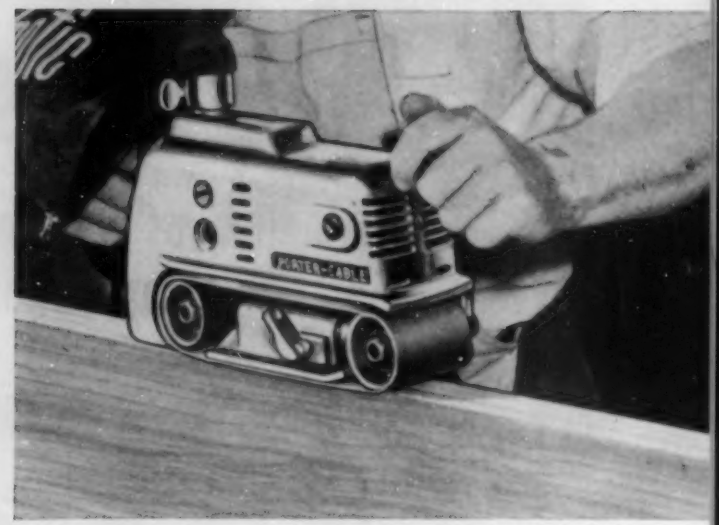
☐ **GEC-1292 RESISTORS**

Name..... **Company**.....

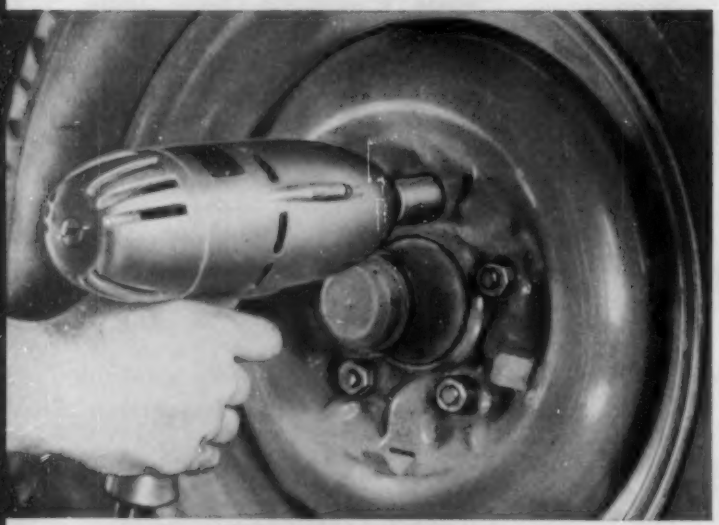
City..... **State**.....

General Electric Engineers Help

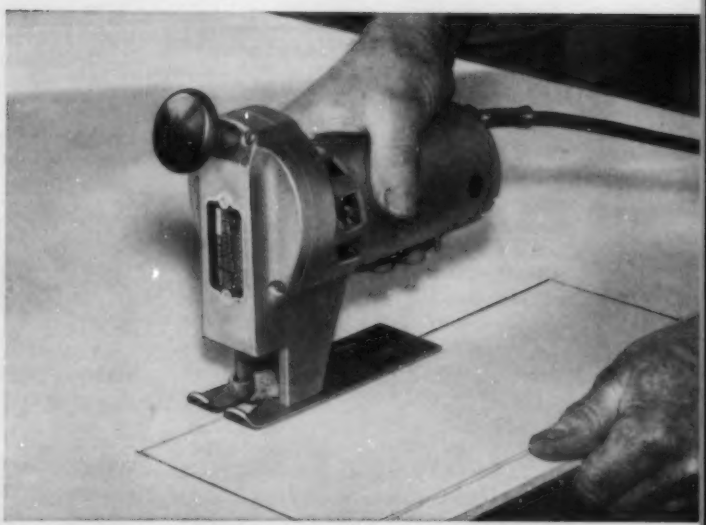
Spinner Edger, American Floor Surfacing Mach. Co., Toledo



Belt Sander, Porter-Cable Co., Syracuse, N. Y.



Impact Tool, Miller Falls Co., Greenfield, Mass.



Sabre Saw, Peninsula Tool Co., Menominee, Mich.

Garden Tiller, Rototiller, Inc., Troy, N. Y.

Smoothie Sander, Clarke Sanding Mach. Co., Muskegon, Mich.

Top Power-tool Manufacturers Solve Motor Application Problems

An Example of G-E Engineering Service Available to You

The eight popular "do-it-yourself" tools pictured here are all powered by General Electric fractional-hp motors. During their design, G-E engineers worked closely with customer engineers to assure proper motor application. As a result of this combined G-E product and engineering service, both tool manufacturers and tool users can count on top performance.

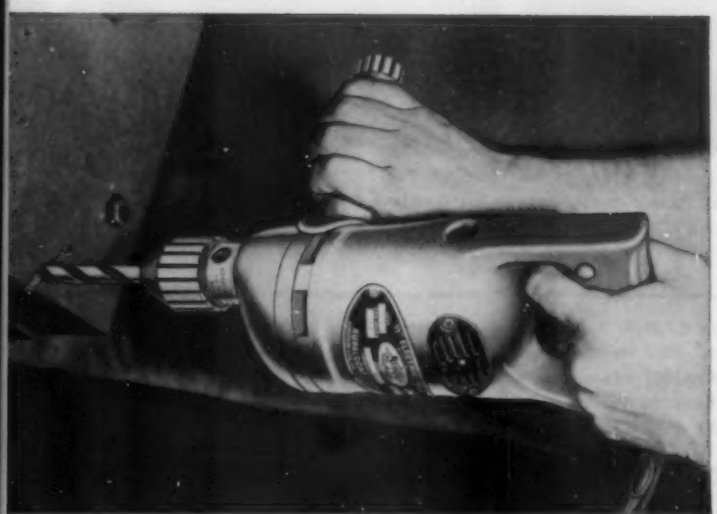
FOR SOME TOOLS, a slight modification of an existing G-E motor design filled the power needs. For others it was necessary to design special motor parts. In one case G-E engineers contributed a suggestion which led to complete tool re-design in order to assure top motor performance. In every case G-E fhp motor engineers—making use of G.E.'s unequalled development facilities—provided complete motor application service.

WHATEVER YOUR PRODUCTS—from aircraft components to plant process equipment to home workshop tools—you can get this same help on fhp motor application. And chances are that G-E experience will cover your specific area of need. For in designing, manufacturing, and applying over *100,000,000* fhp motors, G-E engineers have worked with customers on thousands of different products.

ACT TODAY to put your motor problems in the hands of the motor industry's leading application engineers. Just contact your nearest G-E Apparatus Sales Office. General Electric Co., Schenectady 5, New York. 704-38

Progress Is Our Most Important Product

GENERAL ELECTRIC



½" Sioux Drill, Albertson & Co., Inc., Sioux City, Iowa

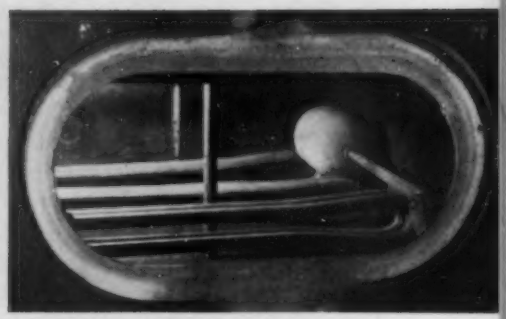
Impact Tool, Ingersoll-Rand Co., Athens, Pa.

Nine product designs show how you can reduce costs, get freedom of design with General Electric Calrod* heaters

HEATING LIQUIDS

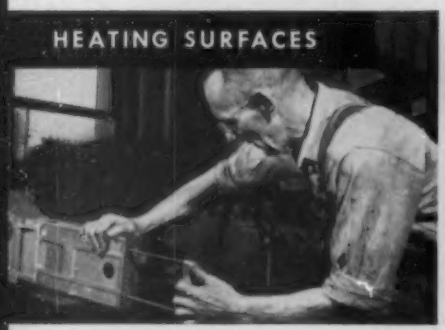
EASILY FORMED tubular heaters improve paint sprayers. Labor time and amount of thinner are reduced 50%.

MANUFACTURER USES IMMERSION HEATERS in sterilizer because G-E heaters take wear and tear of 24-hour duty—provide sanitary sterilization.



DESIGNER SPECIFIED G-E immersion heaters for steam cooker because they are adaptable to small area.

HEATING SURFACES



G-E TUBULAR HEATERS are used in packaging machine because they can be formed into intricate shapes.

BENT SEVEN TIMES, G-E Calrod tubular units don't break. Tire retreader manufacturer had to send other heaters back for special bending.

MANUFACTURER FINDS G-E Calrod "wrap-around" tubular heaters are easy to install in extruder.

HEATING PROCESS AIR

COMPACT G-E FIN HEATERS require less space, allow maximum air circulation for oven manufacturer.

MANUFACTURER PREFERS G-E strip heaters for air-heating oven. Electric heaters are easily installed; eliminate cost of auxiliary equipment.

SIMPLE PATTERN of General Electric strip heaters for radiant drying bank reduces installation costs.

*Reg. trademark of the General Electric Company.

MODERN HEAT PROCESSING . . .

Tear out this coupon and send for your free copies of the bulletins listed at the right.

Name.....

Company.....

Street.....

City.....State.....

Section B723-2, General Electric Company, Schenectady 5, N. Y.

- ☐ GEA-5077 Heating Liquids
- ☐ GEA-5097 Heating Surfaces
- ☐ GEA-5096 Heating Process Air
- ☐ GEA-5866 Calrod Heaters for Machinery Manufacturers

For more information, contact your local G-E Apparatus Sales Office.

GENERAL ELECTRIC

Announcing...

A new chemical rubber from Du Pont

HYPALON®

(Chlorosulfonated Polyethylene)

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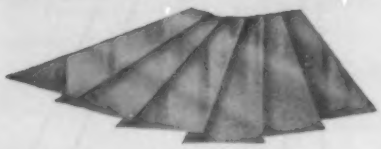

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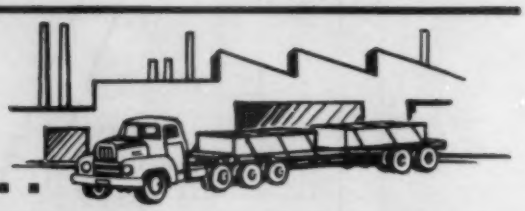

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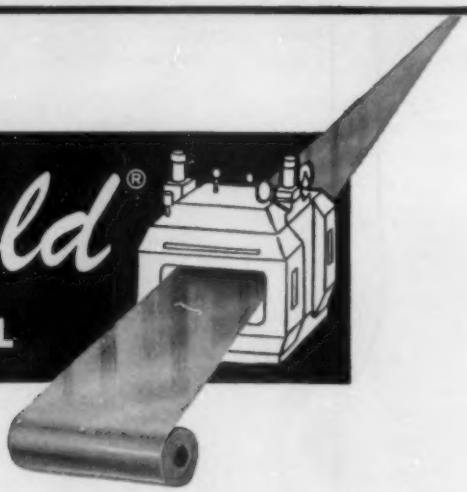

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Perspectives

DESIGN AND DEVELOPMENT

THE PATENT OFFICE SITUATION

Recently, an official in the Patent Office was discussing the dilemma of the backlog of patent applications: "During World War II we almost caught up—our backlog was just under 100,000." His enthusiasm was compared to the present backlog of 205,000 patent applications, with the number increasing monthly. With the present arrangement, it takes more than three and one-half years before an inventor finds out whether his patent is granted or refused.

The situation could only grow worse, so last year the Department of Commerce, at the direction of the Senate Appropriations Committee, set up the Advisory Committee on the Application of Machines to Patent Office Operations. At the head of this 12-man committee was Dr. Vannevar Bush. Their recommendations, as just published are: (1) The Patent Office should put machine searching of compositions of matter on an operational basis; (2) The reclassification of patents should be accelerated; (3) A research and development unit should be established in the patent office; (4) The National Bureau of Standards and the Patent Office should undertake a joint program to develop machines and techniques specifically adapted to the Patent Office operations; (5) An advisory committee should be attached to the office of the Sec. of Commerce to stimulate and coordinate the program within the Commerce Department.

Actually, the work of the committee was restricted to finding a way to speed up the search operation. This phase of patent processing involves a complete investigation and comparison of the specific claims in a new patent with all the claims and disclosures of hundreds of earlier patents. It is estimated that the examiner spends 60 per cent of his time on searching the "prior art," with the remaining 40 per cent taken up with reading the claims of the new patent, writing the decision, and re-examination of the application if necessary. At this rate, 610 patent office examiners manage to get out around 40,000 patents each year. Even so, about 75,000 new applications come in per year. But all the work does not necessarily end here. For those patents which are not allowed are usually refiled with amendments added, and the examiner searches again. The usual go-around is three times, after which the applicant, if not successful by this time, usually gives up.

BIG INCREASE

In the examiner's files as of 1900, there were 1,200,000 U. S. patents, foreign patents, and technical literature. As of 1955 the number of U. S. patents alone had jumped to 2,700,000, and the foreign patents to over 5-million. Over the same period, the number of patent applications disposed of annually (either allowed or refused) by the average examiner fell from 235 in 1900, to 100 in 1955. The inventions grew more complex, and the size of the

(Continued on page 125)

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average patent, measured by pages of specifications and sheets of drawing, grew 100 per cent. Today's muddle is the result. Increased manpower, that is, more examiners, according to the proponents of mechanization, is not the answer. By using this approach, they say, the Patent Office would, in time, grow into a huge unmanageable organization.

RECLASSIFICATION NEEDED

It has been said that the proper classification (there are now 420 different classes) of patents is the most important tool which the patent examiner uses in his work; yet many of the classes have not been totally reclassified for a number of years. For example: 16 classes have not been reclassified since 1901; and 25 more have not been reclassified since 1919. Thus, since 65 per cent of the present patents should be reclassified, in view of recent technological advances, this useful tool is only one third efficient. The aircraft, television, and the electronics field in general have grown so fast that the related patents must be subdivided every few years. The committee agreed that no one subclass should hold more than 100 patents.

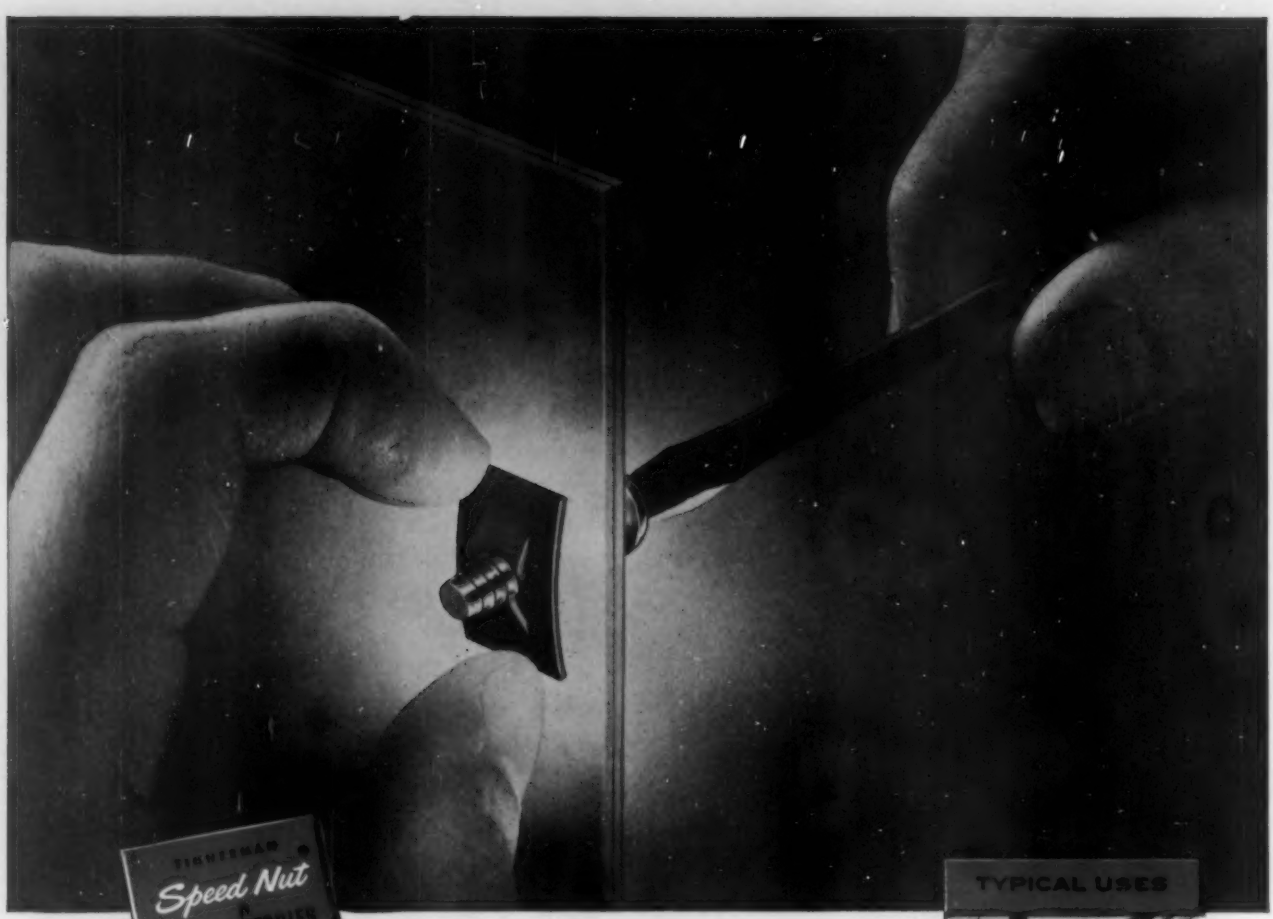
SEARCHING WITH MACHINES

Many companies are using mechanical means for data handling, and the designers of these machines have developed the art to a point where a workable system could be adapted to the patent search process. Such a system would indeed be involved, and would have to hold all of the important characteristics necessary for the analysis of the patents to determine the factors to which the search could be directed. In addition, there would have to be a means of encoding and recording these characteristics on storage devices like magnetic tape or wire, photo-sensitive materials or punched cards. There also must be a method for rapidly identifying any patents having the characteristics searched for, and a means for getting the desired patents (both specifications and drawings) or a reproduction of them. This system should also have provisions for future growth and changes, particularly for handling additional information acquired during other searches. With all these requirements, the system would have to be able to handle 700 such searches a day.

THE HUMAN APPROACH

In spite of the claims made in favor of mechanization, there is still a good sized group of patent attorneys—most of them former examiners—who feel that mechanization is not the answer; that no machine could possibly be made which would take the place of an examiner and his many years of intimate knowledge of his field. There are many instances where an inventor or patent attorney runs up a blind alley searching for the prior art of a particular item, and turns to the examiner in that field for the answer. The solution is, therefore, more examiners, and with them more funds to the Patent Office for its improvement plans and yearly operation.

Furthermore, increasing the patent fee (presently $60—of which $30 is for search and written decisions, and $30 for printing) is not the answer. The Patent Office should not be made to be self-supporting. There are many benefits accruing from the patent office for which the entire public should be made to pay.



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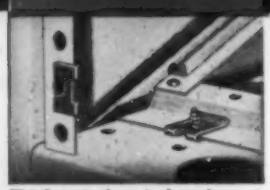

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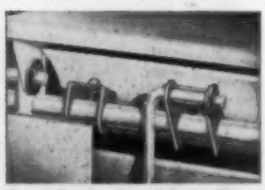

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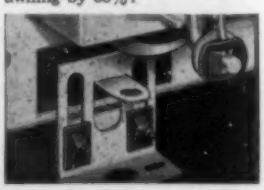

SPEED NUTS lower assembly costs 40% on casement-window air conditioner!

An Engineer Speaks Out

ENGINEERS WILL APPLAUD Dr. Harry S. Rogers' defence of engineering college graduates. As reported in the *New York Herald Tribune*, the president of the Polytechnic Institute of Brooklyn courageously minced no words in taking issue with the statement by Dr. A. Whitney Griswold, president of Yale University, who had said that the future student of Yale would not be "a beetle-browed, highly specialized intellectual."

Although he did not quote Dr. Griswold, Dr. Rogers pointed out that "no university graduate ever becomes worth his salt until he does specialize. . . . There can be no doubt that the engineering college graduate—survivor of a tough exacting discipline, in which only about one-half survive—is well prepared for the real, personal, and intellectual growth which men of culture experience in the exciting years of maturation."

Dr. Rogers is to be highly commended for his forthright speech. The proponents of liberal arts courses have been highly aggressive in their condemnation of engineering graduates. It appears that they cry out that the engineer shall be a liberal arts graduate as well as an engineer. If it is highly important that an engineer have a liberal arts training is it not equally important that a liberal arts college graduate should also have an engineering education? Dr. Griswold says "no," and thereby implies that engineers are of relative small value to our national welfare.

Perhaps it is the rapidly increasing number of engineers who are assuming the top management role in industry that has stimulated the present upsurge of criticism of engineers and the strong laudatory statements concerning the essentiality of liberal arts graduates. Or perhaps it is because the pay of new engineering graduates is much greater than that of the recent graduates of liberal arts colleges. Whatever may be the reason, the criticisms voiced by the liberal arts proponents seem to ignore some basic facts.

As pointed out by Dr. H. S. Rogers, does not the study of calculus and other higher mathematics develop abilities to do critical thinking, as does the study of philosophy? He dwelt on many other aspects of the problem and gave a comprehensive answer to those who overemphasize liberal arts education. As Dr. Rogers pointed out, no college graduate is worth his salt until he has mastered a speciality, be it law, medicine or selling. This brings up another thought.

If in the U.S.A. engineering is to be greatly subordinated or eliminated in favor of the teaching of liberal arts and the humanities, who will there be to "carry on" our technical know-how, run our great industrial plants, provide the goods and services that have made the U.S.A. the envy of the world.

Liberal arts and the humanities are essential. They are the basis of our culture and no nation can long endure without an appreciation of the humanities.

What the all-out proponents of liberal arts fail to emphasize is that it takes all kinds of people to keep the world going and growing. Liberal arts specialists is one kind. Engineering specialists is another kind. It is rather pointless to criticize one for not being the other. And as pointed out by Dr. Rogers, graduate engineers are just as well equipped to grow into mature persons as are graduates of liberal arts colleges, possibly even better equipped.

George F. Bodenschatz

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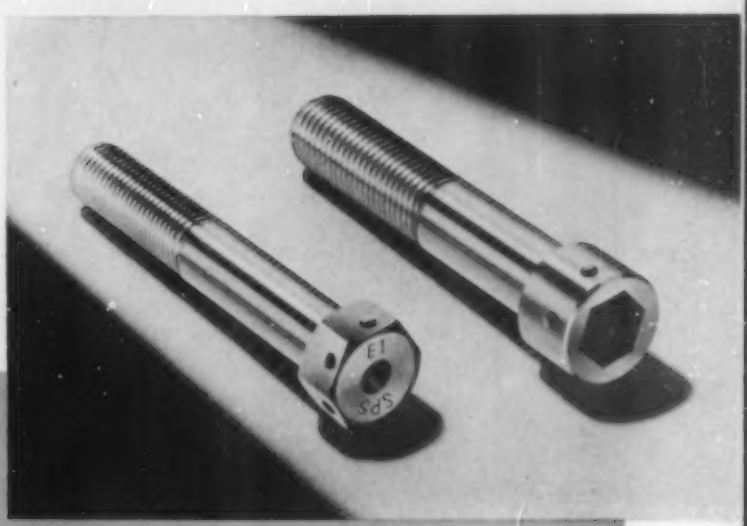


Fig. 1—Titanium parts can now be fastened with titanium bolts to avoid galvanic corrosion from dissimilar metals in contact; strength is comparable to steel and better than aluminum. These titanium bolts are made by Standard Pressed Steel Co.

Strength of TITANIUM BOLTS

As a structural material titanium offers high strength-weight ratio and good strength at 800 F combined with excellent corrosion resistance (Annual Handbook 1953, page B10). Methods of producing sheet and strip are developed, and forgings can now be produced (July 1954, page 172 and December 1954, page 129).

But the assembly of titanium parts remains a problem. Welding techniques are yet to be perfected. Threaded fasteners should be of equal corrosion resistance and strength-weight ratio.

Strength of titanium alloy bolts was investigated by the Naval Air Experimental Station. Tensile, shear and endurance properties were compared with steel, stainless and aluminum bolts of the same dimensions. Here are the results.

* JOSEPH VIGLIONE, METALLURGIST, NAVAL AIR MATERIAL CENTER, PHILADELPHIA, PA.

As PART OF A PROGRAM to develop mechanical fasteners the Naval Air Experimental Station was commissioned to investigate and evaluate the strength characteristics of titanium alloy bolts. An assorted number of various types of bolts fabricated from RC-130B, Ti-150A, RS-120 and RC-70 titanium alloys were tested. It was found that the mechanical properties of titanium bolts made from different alloys were practically equal except for fatigue strength. The ☆ in titanium bolt was selected as a basis for relative evaluation, using the best and the poorest titanium bolt (fatigue strength as criterion) for a comprehensive comparison of titanium, steel, stainless steel and aluminum bolts.

A summary and an analysis of the test data led to the following general conclusions:

——The ultimate tensile strength and the double shear strength of the titanium bolts compare very favorably with those of steel bolts in terms of

* *The opinions expressed are those of the writer and are not to be construed as official for reflecting the views of the Navy Department or the Naval Service at large.*

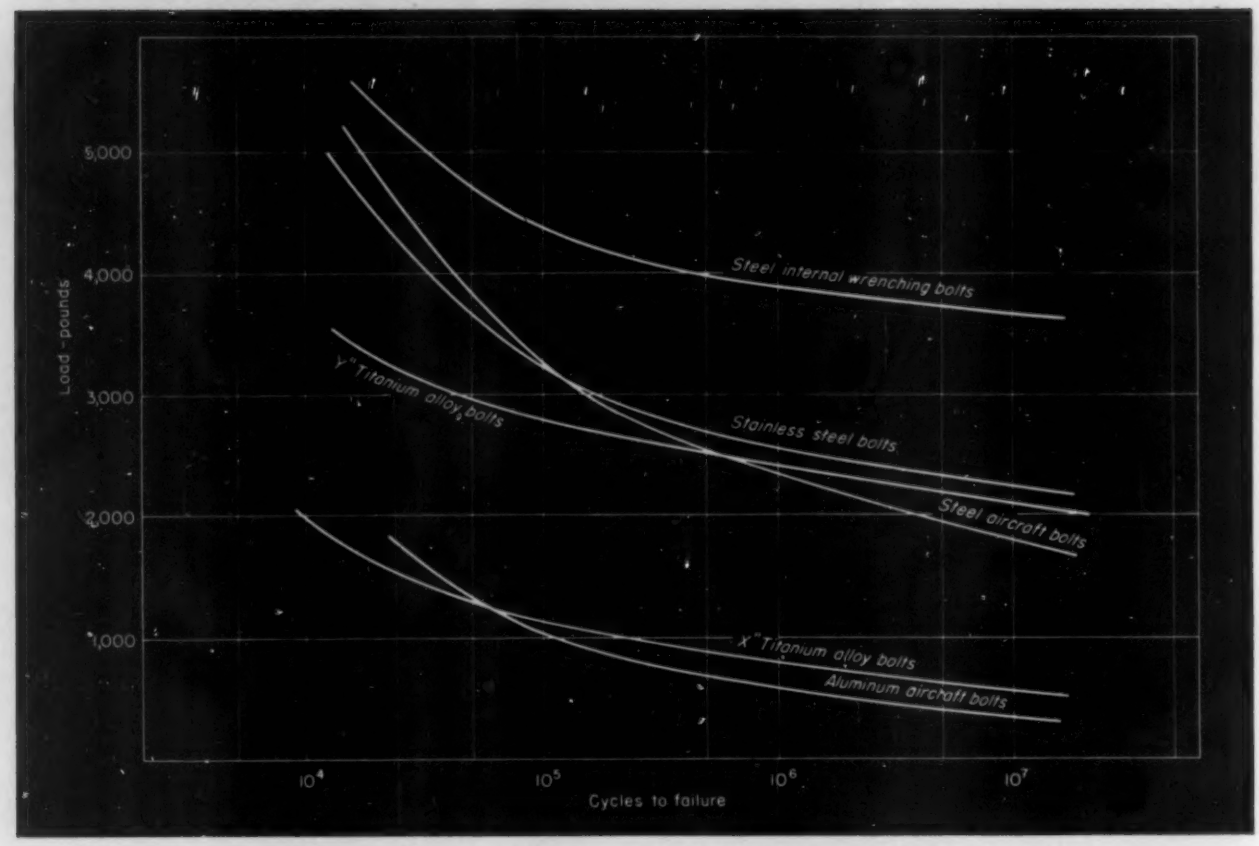


Fig. 2—Fatigue Strength Curves. Of the several titanium alloys tested, Alloy Y was the best and Alloy X the poorest.

absolute values, and are much superior if compared on a strength-weight basis.

——The fatigue strength of the titanium bolts is greater than that of the standard low strength steel aircraft bolt, but inferior to that of the close tolerance high strength steel internal wrenching bolt, if evaluated in terms of absolute values. However, if judged on a weight basis, the titanium bolt is approximately equal to the steel internal wrenching bolt in fatigue strength and has double the fatigue strength of the steel aircraft bolt.

——The ductility of the titanium bolts, as measured by the elongation of the grip lengths at approximately 60 per cent of the ultimate tensile strength was greater than the steel bolts.

——The mechanical properties of the aluminum bolts were found to be much inferior to those of the titanium bolts, whether compared in terms of absolute values or on a strength-weight basis.

TEST DETAILS

Prior to testing, radiographic and fluorescent penetrant inspection was made of each titanium bolt to make certain that all bolts tested were free of detectable flaws. Head structure and grain flow were examined by micro and macro inspection as a check for metallurgical defects and evidence of good head forming and thread rolling technique.

A Krouse Direct Stress Fatigue Testing Machine was used in performing the fatigue tests. This machine utilizes the deflection of a load lever as a means of determining the amount of force applied to the specimen. By a system of flex plates the angular lever motion is transformed to a straight line motion to induce direct axial loading onto the specimen. The load lever is actuated by an infinitely variable throw crank which makes it possible to obtain all ranges of tension and compression within the capacity of the machine.

The bolts were subjected to 1100 cycles of repeated loadings per minute. The range of load applied to the bolts during each pulsating cycle of tensile load varied between a preload value of 10 per cent of a predetermined maximum and the maximum, for a load ratio of 0.10.

The fatigue testing machine had been calibrated statically and dynamically to evaluate inertia effects during operation of the machine with tests in progress. Correction factors, obtained from dynamic calibration studies, have been applied to the fatigue data reported here.

The value of the fatigue strengths were obtained by plotting S-N curves and noting, from the curves, the highest fatigue load withstood by each group of bolts at 8 million cycles of loading. Each test was considered complete when fracture occurred outright or a crack formed which caused a drop in load sufficient to shut off the machine automatically.

Ultimate tensile strength and double shear tests were conducted on a Baldwin Universal Testing Machine. Elongation of grip lengths were observed by dial indicator gage. A preload of 200 lb was used as zero to provide for the alignment of bolts and fixtures in the testing machine and for the elimination of backlash in the testing machine and dial gage mechanism.

Table I—Test Results of 5/16 in Titanium, Steel, Stainless and Aluminum Bolts

Material	Type of Bolt	Government Specification	Ult. Strength lb	Double Shear Strength, lb	Fatigue Strength, lb (Note 1)	Fatigue Ratio (Note 2)	Elongation in. (Note 3)
X Titanium Alloy	External Wrenching	.....	9,875	16,525	650	0.066	0.0180
Y Titanium Alloy	Internal Wrenching	.....	9,524	16,950	2,150	0.226	0.0238
Steel	Aircraft	MIL-B-6812	8,475	13,375	1,900	0.224	0.0105
Steel (High Strength)	Internal Wrenching	MIL-B-7838A	11,200	15,565	3,700	0.330	0.0123
Stainless Steel	Machine, 1,200 F	MIL-B-7874	9,070	15,150	2,300	0.254	0.0102
Aluminum	Aircraft	MIL-B-6812	4,160	6,700	400	0.096	0.0098

Note (1) Based on 8 million cycles of stress applications. (2) Ratio of fatigue strength to static strength. (3) Elongation at 60 per cent of tensile strength.
* Units are in lb, not psi.

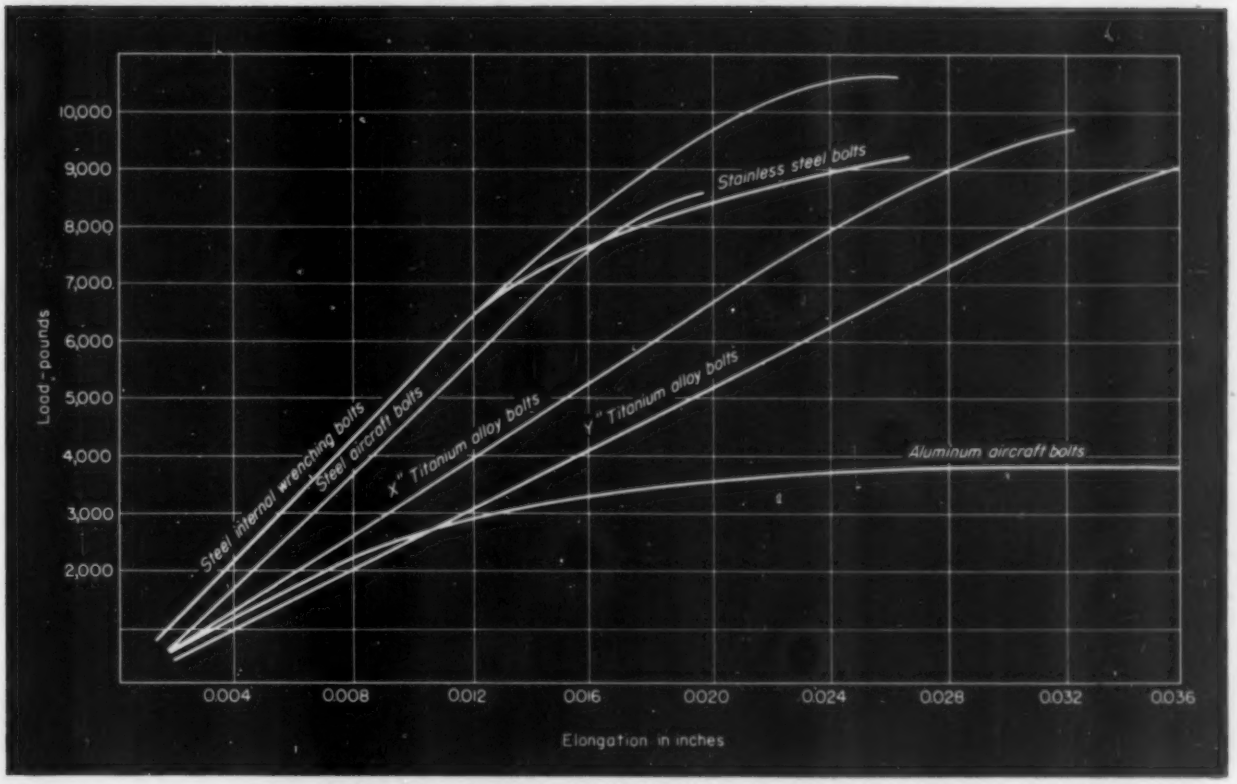


Fig. 3—Elongation—nut to Bolt head—5/16 in Bolts.

The results of the bolt evaluation are summarized and presented in Table I, with the fatigue strengths shown graphically in Fig. 2 in the form of S-N curves. Complete load-elongation curves are shown in Fig. 3, whereas the summarized values of the bolt elongation listed in Table I are for grip lengths (nut to bolt head) and are elongations at approximately 60 per cent of the ultimate strength, an arbitrary value used for evaluating and comparison purposes, since it is known that stresses above 60 per cent of the ultimate strength affect some of the properties of most metals.

The comparative values of tensile, fatigue and shear strengths of ⅜ in bolts on the basis of relative strength-weight ratios of the different materials used in their fabrication is given in Table II. These are calculated quantities and theoretical values used as a means to measure relative strengths on a weight basis. They are not intended to be design criteria.

The value of the static strength of the titanium bolt, as tested, is 85 per cent of the tensile strength of the high strength steel internal wrenching bolt, the strongest of all the bolts examined, and is approximately equal in strength to the stainless steel bolt, better than the low strength steel aircraft bolt and much superior to the aluminum aircraft bolt. If evaluated on a strength-weight basis, the static tensile strength of the titanium bolt surpasses those of all the other types tested. The double shear strength of the titanium bolt, as tested, is better than that of the

steel internal wrenching bolt, and if evaluated on a strength-weight basis, the double shear strength practically doubles that of the steel internal wrenching bolt.

The absolute value of the fatigue strength of the titanium bolt is 13 per cent better than that of the low strength steel aircraft bolt, but only 58 per cent of the superior grade high strength steel internal wrenching bolt. When compared on the weight basis the fatigue strength of the titanium is practically equal to that of the internal wrenching bolt and double that of the steel aircraft bolt.

The values of the tensile, double shear and fatigue strengths of the titanium bolt shows up somewhat better by this type of comparison.

SOME TEST RESULTS

Static failures of bolts normally occur when a specified set of elongation has taken place. As a bolt is loaded, elongation takes place proportionally, until the yield point is reached and then elongation rapidly increases with a given increment of load, until failure occurs. This yield point, which is also indicative of the elastic load limit, is one of the most essential properties of a bolt since it represents the maximum safe load that can be carried. Bolts, more than most metallic parts, require a high degree of ductility as well as great strength.

In compensation for misalignment, interference, fits, and normal tolerance variations, a certain amount of ductility is required to permit the material of the bolts to flow and re-adjust or equalize loadings. The titanium bolts have excellent static strength and high ductility as measured by the elongation at 60 per cent of their ultimate strengths. It has been found that stresses above 60 per cent of the ultimate tensile strength usually affect some of the properties of metals, whereas stresses below the proportional limit or the elastic limit will have practically no effect except to bring about fatigue failure when the stress is applied many times. Titanium bolts have high strength and great ductility and are excellently suited for applications requiring high static and high shear strengths.

The test points are not shown in the composite S-N diagram, but the individual diagrams as plotted during test showed that the curves of the steel and aluminum bolts are uniform—all points practically falling on a smooth curve. In contrast to this, the greater scatter of the test points of the titanium bolts is very apparent. This scatter of test points when conducting fatigue tests has occurred many times before when evaluating titanium base alloys and component parts. Similar extensive scatter occurred when evaluating spot and seam-welded titanium alloy joints, as compared to consistent test results for similar steel and aluminum assemblies. At this stage of development it seems that inconsistency is characteristic of titanium alloys in general when subjected to repeated stress. At the present time, some of the inconsistencies in fatigue properties of titanium alloys are attributed to the effects of trace elements, and of various fabricating variables.

A number of mechanical factors were not taken into account during this investigation, due to the exploratory nature of the project. Among these factors are classes of fit, thread form, manner of rolling threads and forming the heads, squareness of the heads, etc. Each factor has a special significance indicative of its own peculiar harmful effects upon the strength of the bolt. Most of the titanium bolt failures were thread failures, so it must be obvious that the method of forging the heads had little effect upon the fatigue strength of the bolts. It is well to point out that it makes very little difference whether a bolt head is made by the forging method or by being machined from the solid when used in structures subjected only to static stresses. For applications in which fatigue strength and resistance to impact are important, bolt heads should be made by either the hot or cold forging method so that the flow lines are parallel to the directional contours of the fillet and the bearing surface of the heads, to provide optimum conditions for resistance to dynamic stresses. This condition is shown in Fig. 4.

The low fatigue strength of the "X" titanium alloy bolt of 650 lb, as compared to 2150 lb for the "Y" titanium alloy bolt, is partially attributed to better thread rolling technique. Examination of the thread contours of the bolts (Fig. 5 (a)) revealed that the threads of the "X" alloy bolt were rough and jagged, with little evidence of cold work, almost resembling a machine thread in appear-

Table II—Strength Ratios for 5/16 in. Bolts

Made from Same Materials Shown in Table I

Material	Tensile	Double Shear	Fatigue
X Titanium Alloy.....	36.3	59.5	2.4
Y Titanium Alloy.....	35.0	58.0	7.9
Steel.....	17.3	27.8	3.9
Steel (High Strength)...	23.3	32.4	7.2
Stainless Steel.....	18.0	30.1	4.6
Aluminum.....	24.2	39.0	2.3

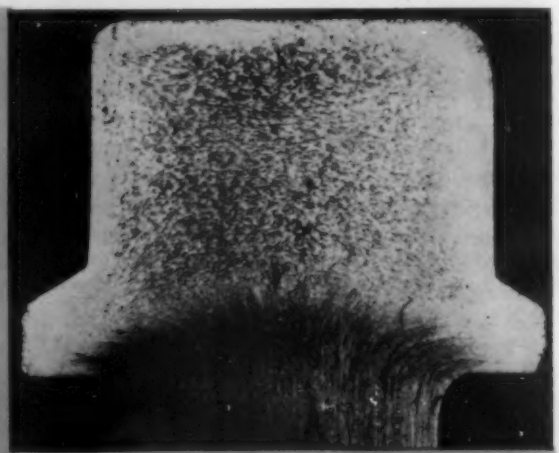


Fig. 4—Etched head of Ti bolt showing flow lines parallel to the contour of the fillet.

ance, although it was known to be a rolled thread. In contrast to this, is the smooth even appearance of the thread of the "Y" alloy bolt with its greater degree of cold work, indicating an advanced stage in thread rolling technique developed by that particular manufacturer.

The static and bending strengths of rolled and machined threads are practically the same, while in the case of dynamic repeated loading, the rolled screw thread offers greater fatigue strength than machined threads, due to the compressive cold working of the thread material by the thread rolling process, Fig. 5(b).

The rough and jagged threads typical of the earlier titanium bolts were sources of additional stress concentration which lowered the fatigue strength of these bolts. The increased fatigue strength of the "Y" titanium alloy is indicative of the marked improvement in the thread rolling technique. The higher fatigue strength of the "Y" titanium alloy bolt was in part due to the fact that this alloy probably has a higher basic material fatigue strength, or a low fatigue notch factor. Increased fatigue strength of titanium bolts is reasonably assured through additional improvement in thread rolling methods applicable to the close-packed hexagonal structure of the titanium metal, and through use of newly developed high strength titanium alloy.

Incidentally, the galling and seizing tendencies inherent to sliding titanium surfaces is further aggravated in the case of titanium bolts with less than perfectly smooth threads. The jagged thread contours, resulting from improper thread rolling technique, would cause threaded members to seize whether on titanium or steel bolts and nuts.

The stainless steel high temperature bolts and the steel and aluminum aircraft bolts were included in this investigation for comparative purposes. All fatigue failures in the case of the stainless steel and aluminum bolts and some failures of the steel aircraft bolts were head failures; indicating a bolt head poorly designed for fatigue resistance because fillets were not used under the heads. A generous fillet would eliminate or at least minimize the stress concentration in this area.

The effect of not having a fillet under a bolt head is most pronounced in the presence of bending due to eccentric loading such as misalignment as a result of lack of squareness of bolt heads and nuts. A greater strength level may be used in the presence of superimposed bending if a generous fillet is used. To demonstrate the effectiveness of fillets, two groups of aluminum bolts were fatigue tested, one with fillets and the other without fillets. A tremendous increase in fatigue life at all stress levels was obtained for the aluminum bolts with filleted heads, as compared to the unfilleted heads. At 8 million cycles of stress, the fatigue strength of the aluminum bolts was increased from 400 lb to 950 lb by machining a fillet under the head of the standard aluminum aircraft bolt.

DESIGN RECOMMENDATIONS

The titanium bolt in its present limited stage of development, can be used advantageously instead of the low strength steel aircraft bolt, since the titanium bolt is stronger and is about 43 per cent lighter in weight. The titanium bolt can be used in place of the close tolerance high strength steel internal wrenching bolt where high shear strength is a primary design criterion, with high static strength and moderate fatigue strength a secondary but not negligible requisite.

The selection of titanium alloy as a bolt material to be used in any one specific application should be determined by consideration of the need to keep weight down to a minimum, corrosive and temperature environment, strength requirements and economic factors. It is obvious that the weight saving advantages of titanium bolts, or other component parts made of titanium alloy, must overbalance the increased cost wherever substitution is made. This is the basic reason for the use of titanium in aircraft and not in other installations where the advantage of weight saving does not warrant the additional excessive cost.

EDITOR'S NOTE—Research and development on fabricated titanium parts go forward. The use of titanium in structural design will depend, to an important degree, upon methods of attachment, electrochemical insulation and precaution in fits with mating parts. Titanium has a high coefficient of friction and will gall badly when in sliding contact with other metals—important when considering titanium bolts.

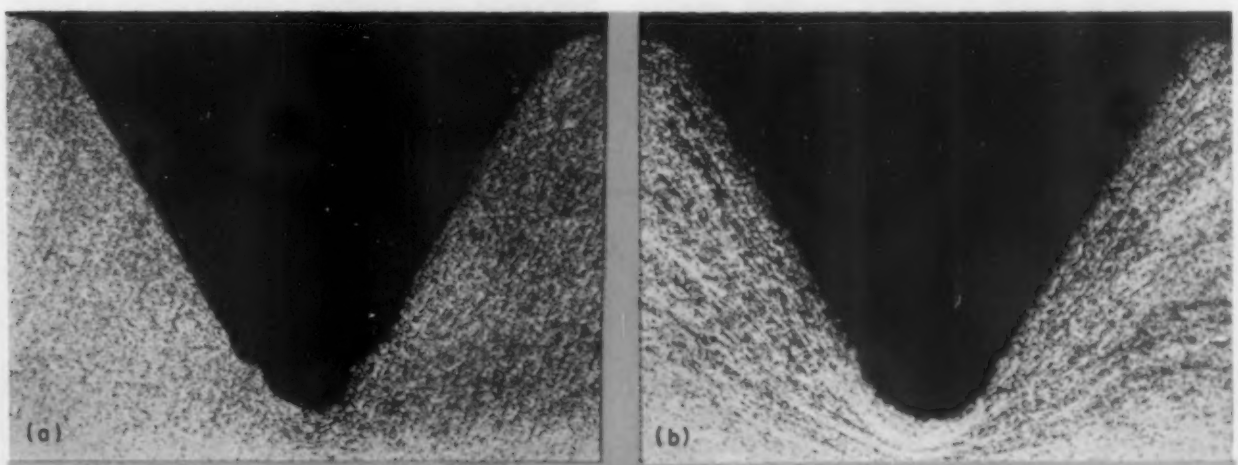


Fig. 5 (a)—Thread contours of Ti bolt. Note roughness at root of thread caused by lack of cold working. (b)—Thread contour of Ti bolt showing results obtained by complete cold working.

Operating From

IRWIN B. GALTER
Development Engineer, Lear, Inc.

EDITOR'S NOTE—Three-phase motors are more efficient, more reliable, have longer life, and are less hazardous in explosive atmospheres than are single-phase motors. In addition, three-phase motors of over 1 hp cost less than single-phase units of the same rating, and the difference increases with rating. Equipment likely to be used where only single-phase power may be available, such as light industrial, residential, and rural areas, ordinarily requires use of a single-phase motor despite these advantages.

Three-phase motors can be operated from single-phase lines using static phase adapters comprised of low-cost electrical components—capacitors, resistors, and inductors —which are connected in a combination depending upon characteristics of the load. These three-phase adapters can supply loads such as lamps, transformers, induction motors of squirrel and wound-rotor types driving air conditioners, compressors, generators, pumps, fans, blowers, saws, printing presses, and other loads of an essentially constant nature. Starting torque must be reasonable.

ADVANTAGES. A prime advantage of using phase adapters is the increased utility of the equipment of which it is a part. Such equipment can be used in areas where three-phase power may not be available. If three-phase power becomes available the equipment can be converted to three-phase operation by a simple change of power connections. A second advantage lies in the possibility of improved equipment performance or increased equipment capacity, because three-phase motors operating from a phase adapter draw substantially less starting current than do comparative single-phase units. As pointed out in *Electrical World*, May 3, 1953, page 74, current limitations of single-phase lines restrict motor sizes to approximately 5 to 7.5 hp because of high starting currents. With a phase adapter a 10-hp 3-phase motor can be used without exceeding starting-current limitations.

DISADVANTAGES. One disadvantage of phase adapters is that each one is normally designed for a specific load, thus making them generally unsuitable for use in applications where the load varies. A second disadvantage is that the starting torque of a three-phase motor operated from an adapter is substantially less than that of a single-phase repulsion-induction motor of the same rating.

SUMMARY OF STATIC PHASE-ADAPTER DESIGN PROCEDURE

STEP 1. Determine the equivalent motor phase-impedance by the two watt-meter method or other suitable means.

STEP 2. Draw the vector diagram of the desired phase-voltages and currents as shown in Fig. 5.

STEP 3. Determine from X-to-R ratio of the load or from the vector diagram if equal phase voltages can be obtained by the addition of capacitive impedance or if an additional inductive impedance is required in the network.

STEP 4. If it is advantageous to use a Z_{RL} impedance in the phase adapting network, draw a family of I_{RL} circle diagrams of various radii.

STEP. 5. From these circle diagrams and consideration of (A) the effects of component production tolerances, (B) steady-state power dissipation and (C) motor acceleration, select the values of Z_{RL} and Z_{RC} that will provide an optimum design.

Three-phase Motors Single-phase Supply

Static phase adapters can decrease equipment costs — initial, operating, maintenance, and repair — and can increase equipment utility, performance, capacity, and life. Adapters are low-cost, compact assemblies of simple electrical components. But use is primarily limited to motors or other devices with essentially constant operating loads.

The three-phase motor cannot then be connected to loads requiring unusually high starting torque unless some provision is made for reducing torque requirements until the motor approaches normal operating speed.

PHASE ADAPTER APPLICATION. In integrating a phase adapter as a component of a machine or equipment, heat dissipation, overload protection, load requirements, and careful adapter design are prime considerations. An adapter is comprised of one to four electrical components, the number depending upon the electrical characteristics of the load with which it is used. The adapter may consist of: (1) a capacitor; (2) a capacitor and resistor; (3) a capacitor, resistor, and inductor; or (4) a capacitor, inductor, and two resistors. The required number and electrical values of these components are determined by using the design method described here.

Heat dissipation in both capacitor and inductor is generally negligible since they are essentially reactive or wattless devices. Resistors used as part of the phase-adapter network do produce heat. The amount of heat developed for a particular load application can be determined from design calculations as shown later. Provisions must be made to dissipate this heat safely.

Three-phase overload protection should also be included with provisions for separate adjustment for each phase because under some operating conditions the phase currents may be unbalanced.

The driven load should be equal to, but not greater than, the normal rated full-load output of the three-phase motor. Loading the motor beyond the rating will cause high phase-current unbalance with consequent vibration, noise, and overheating. The adapter must be carefully designed and the tolerances of the components maintained within close limits in order to produce equal phase voltages. At full loads phase current unbalance can be 6 to 10 times the voltage unbalance, or greater. This produces the same undesirable effects as overloading.

PHASE-ADAPTER DESIGN. The design method presented in the following paragraphs is described by Irwin B. Galter. Using this method electrical component values may be determined with a relatively simple graphic analysis of the design problem. Although the calculations shown are for 400-cycle equipment, the method is equally valid for other power frequencies.

DESIGN METHOD

Static phase adapter design is derived from the vector voltage and current relations present in three-phase circuits. A three-phase delta-connected load is shown in Fig. 1(A). The design theory and procedures discussed in this article may be applied to any type load, but the three-phase load referred to will be assumed to be a squirrel-cage motor. Assumed phase rotation will be *AC-CB-BA*.

The voltages across each phase (E_{BA}, E_{AC}, and E_{CB}) are equal and are displaced in phase by 120 deg from each other, as shown in (B) in polar form. The currents in each phase (I_{BA}, I_{AC}, and I_{CB}) are equal and lag the voltages by the angle θ.

When a three-phase motor load is placed across a

single-phase supply, the single-phase voltage is applied across terminals A and B of Fig. 1(A). The phase-voltage relationships are then indicated by the solid-line vectors of Fig. 2(A) shown in polar form. In this case the E_{AC}, and $E_{C'B}$ voltages across phases AC and CB stand at less than 120 deg with respect to each other, and are smaller than the normal three-phase line voltages E_{AC} and E_{CB}.

Phase-adapter design is simplified by the fact that the Z_{BA} phase of the motor windings is in parallel with the other two branches, as shown in Fig. 1(A). Regardless of the loads placed across A to B, the magnitude of E_{BA} will remain constant providing the single-phase power source is able to handle increased loading. The phase impedance Z_{BA} may therefore be neglected in the considerations to follow; and the equivalent-load circuit is then reduced to Z_{AC} and Z_{CB} in series. The voltage and current relationships then present are shown in Figs. 2(A) and (B) in polar form. In (B) vectors $I_{BC'}$, and I_{BC} are also shown because they are concerned with the method used in the solution of adapter design problems. Vectors $I_{AC'}$, and $I_{C'B}$ are the currents of phases AC and CB respectively. Impedances Z_{AC} and Z_{BC} are inductive, and their currents lag their voltages by the angle θ, as indicated.

The phase adapter designed for the typical load problem performs two functions. First, the $E_{AC'}$ and $E_{C'B}$ voltages across phases AC and BC in Fig. 2(B) must be increased to equal the normal three-phase voltages E_{AC} and E_{CB}. Second, the $E_{AC'}$ and $E_{C'B}$ voltages must be rotated in phase, each in a direction opposite the other, to obtain the desired 120 deg relationship between them. These functions are obtained in the following manner.

The voltage and current relationships of phases AC and CB are shown in Fig. 2(B) during single-phase excitation and without phase correction. If a forcing current as indicated by the dashed-line vector I_{BC} is added in phase with the vector sum of $I_{CB'}$ and $I_{AC'}$, important changes in the magnitudes and angular relationships of the phase currents occur, as is shown in Fig. 2(C). This corrective forcing current is produced most simply by the addition of a capacitive impedance across phase BC, as shown in Fig. 3. Current $I_{BC'}$ and its negative counterpart $I_{C'B}$ are rotated in a clockwise direction, current $I_{AC'}$ is rotated counterclockwise, and at the same time, their magnitudes are increased. Simultaneously, the voltages across each phase are increased and rotated in the same direction as their respective currents. When I_{BC} is the proper magnitude the phase currents and voltages will be increased to the correct magnitudes and shifted to the proper angular relationship as indicated by the shift and increase of the following quantities shown in Fig. 2(C):

$I_{BC'}$ to I_{BC}
$I_{AC'}$ to I_{AC}
$I_{C'B}$ to I_{CB}
$E_{AC'}$ to E_{AC}
$E_{C'B}$ to E_{CB}

The validity of this method is established by the following relations. In Fig. 3 current I_{AC} is equal to the vector sum of capacitive-impedance current I_{BC} and motor-winding current I_{CB}, or:

$$\vec{I}_{AC} = \vec{I}_{BC} + \vec{I}_{CB}$$

Hence the capacitive-impedance current $\vec{I}_{BC}$ is equal to the vector difference of motor-winding currents $\vec{I}_{AC}$ and $\vec{I}_{AB}$.

$$\vec{I}_{BC} = \vec{I}_{AC} - \vec{I}_{CB}$$

but $$\vec{I}_{CB} = -\vec{I}_{BC}$$

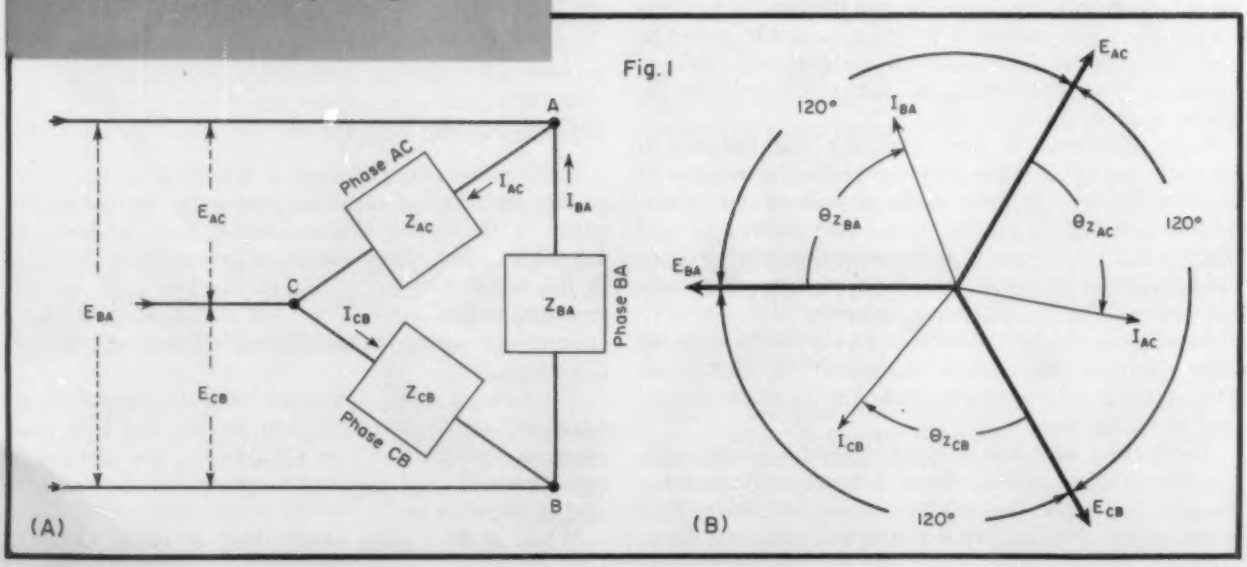
and $$-\vec{I}_{CB} = \vec{I}_{BC}$$

therefore $$\vec{I}_{BC} = \vec{I}_{AC} + \vec{I}_{BC}$$

The magnitude and phase angle of Z_{BC} is then necessarily equal to E_{CB}/I_{BC}, which is a capacitive impedance.

Fig. 1—Three-phase delta-connected load showing current and voltage connections and relationships. (A) Individual-phase connections and impedances. (B) Polar representation of phase-voltages and phase-current angular relationships. Angular difference between voltage and currents is indicated by the angle θ.

Fig. 1



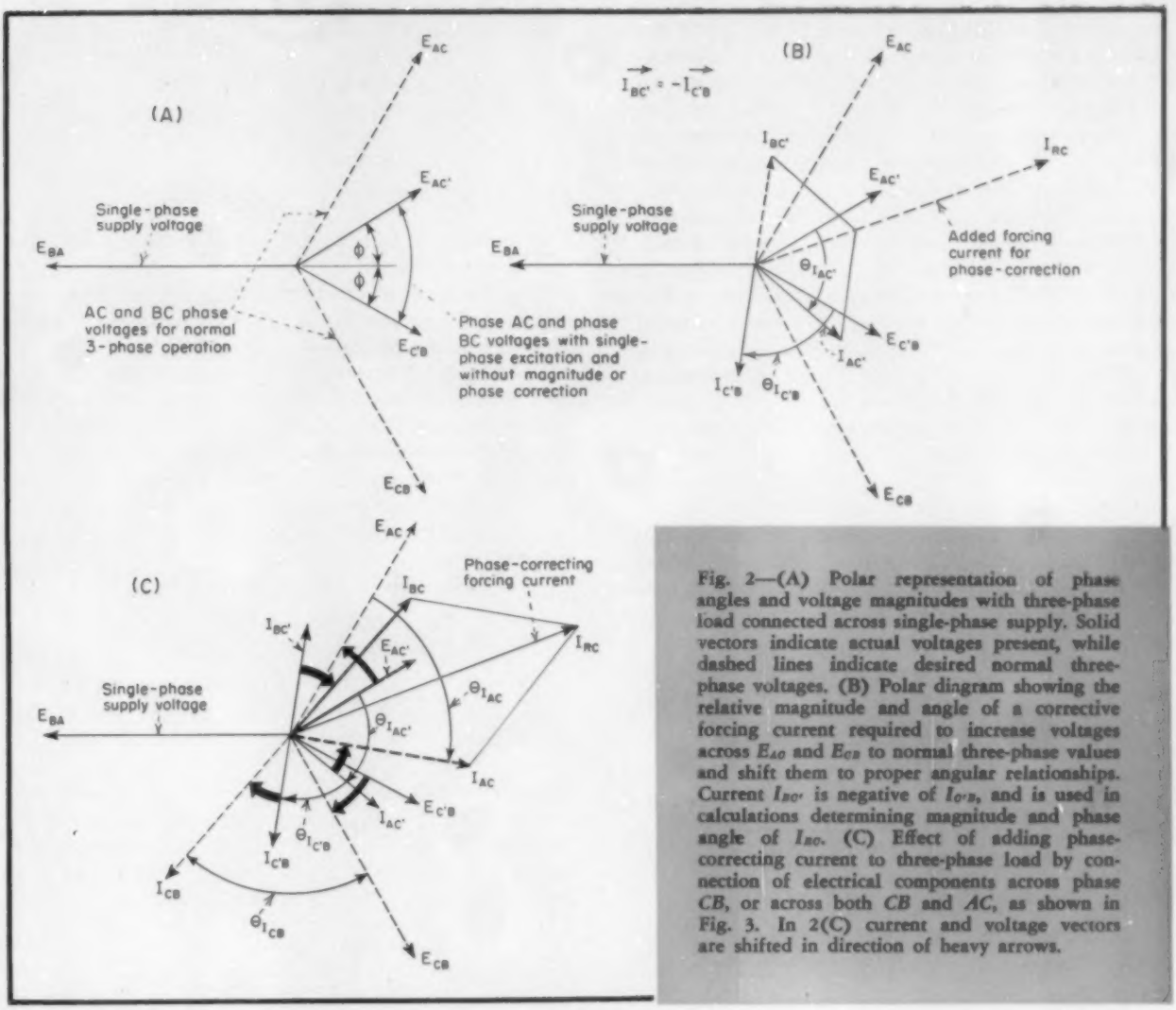

(A)
Single-phase supply voltage
AC and BC phase voltages for normal 3-phase operation
Phase AC and phase BC voltages with single-phase excitation and without magnitude or phase correction
(B)
Single-phase supply voltage
Added forcing current for phase-correction
(C)
Single-phase supply voltage
Phase-correcting forcing current

Fig. 2—(A) Polar representation of phase angles and voltage magnitudes with three-phase load connected across single-phase supply. Solid vectors indicate actual voltages present, while dashed lines indicate desired normal three-phase voltages. (B) Polar diagram showing the relative magnitude and angle of a corrective forcing current required to increase voltages across E_{AC} and E_{CB} to normal three-phase values and shift them to proper angular relationships. Current $I_{BC'}$ is negative of $I_{C'B}$, and is used in calculations determining magnitude and phase angle of I_{BC}. (C) Effect of adding phase-correcting current to three-phase load by connection of electrical components across phase *CB*, or across both *CB* and *AC*, as shown in Fig. 3. In 2(C) current and voltage vectors are shifted in direction of heavy arrows.

The required magnitude and phase angle of this capacitive impedance is dependent upon the individual phase impedance. In a special case only a pure capacitance may be needed. In other cases the further addition of an inductive impedance across phase AC, as shown in Fig. 3, is required. The procedure required to determine the number and values of these added components is described in the following paragraphs.

DESIGN PROCEDURE

The first step in phase adapter design is determination of the individual-phase impedance and current flow of the three-phase load which the adapter is to supply. For a motor, the impedance which each phase presents to the line when the motor is running at normal operating speed and load is the equivalent motor-phase impedance. This may be determined by the two-wattmeter method or other suitable means. The equivalent circuit of the motor load is shown in Fig. 1(A). Z_{BA}, Z_{AC}, and Z_{CB} are the equal equivalent impedences of phases *BA*, *AC*, and *CB*, respectively. For design purposes, only Z_{AC} and Z_{CB} as shown in Fig. 3 need be considered.

If the inductive-reactance to resistance ratio of the motor-phase load is the tangent of 60 deg, or 1.732, the vector sum of I_{AC} and I_{BC} coincides with the line, $V_{CB} + 90°$; and equal phase voltages can be obtained by connecting a pure capacitance across phase *CB*. For all cases the value of the capacitor in microfarads can be calculated using the equations:

$$X_C = \frac{E_{CB}}{I_{BC}}$$

$$C = \frac{10^6}{2\pi f X_C}$$

where X_C is the capacitor reactance and f is the line-voltage frequency.

If the ratio of motor-phase X_L-to-R is greater than 1.732, equal phase voltages can be established by connecting a capacitive impedance (capacitor and resistor) across phase *CB*. If the ratio of X_L-to-R is smaller than 1.732, a capacity and negative resistance would be required to equalize the voltages. This is an impractical solution; instead, the proper voltages are obtained by adding an inductive impedance across phase *AC* in addition to the usual capacitive impedance across phase *CB*, as shown in

Fig. 3. Fig. 4 is essentially the same as Fig. 2(C) except that only the final corrected values of current and voltages are indicated, together with I_{RC} and the impedance angle established by the line $E_{CB} + 90°$.

A complete solution to the problem of equalizing phase voltages can be effected using a vector diagram similar to Fig. 5. Any number of Z_{RL} and Z_{RC} combinations can be used to obtain the proper phase voltages. For a specific problem, all currents in the vector diagram should be drawn to scale so that their magnitudes and phase angles may be accurately determined. In Fig. 5 the principal axes have been rotated 60 deg clockwise compared to previous diagrams. The circle locii of I_{RL} indicate the path that the head of vector I_{RL} must follow with a given resistance R and variable-inductance L.

Fig. 3 shows circuit connections which produce the following vector relations:

$$\vec{I}_{AC} + \vec{I}_{RL} = \vec{I}_{CB} + \vec{I}_{RC}$$

In Fig. 5 these summations are made by placing the tail of vector I_{RL} at the head of vector I_{AC} and the tail of vector I_{RC} at the head of vector I_{CB}. The vector sum of I_{AC} and I_{RL} and the sum of I_{CB} and I_{RC} coincide at the point of solution. Typical solutions are indicated as 1, 2, 3, 4 and 5 in Fig. 8.

The equations:

$$\vec{Z}_{RC} = \frac{\vec{E}_{CB}}{\vec{I}_{RC}}$$

and

$$\vec{Z}_{RL} = \frac{\vec{E}_{AC}}{\vec{I}_{RL}}$$

are used to evaluate the corrective capacitive and inductive impedances.

Z_{RC} may be reduced to a pure capacitance, thus reducing the total required components to three. This may be accomplished by selecting the values of R_L and L so that the sum of I_{RL} and I_{AC} falls on the line $E_{CB} + 90°$. Of the five solutions indicated in Fig. 5, four fall on this line.

There is a maximum limit to which R_L can be increased, and at this limit the circle locus of I_{RL} is tangent to the line $E_{CB} + 90°$.

ADDITIONAL FACTORS

In addition to proper phase-voltage balance other factors must be considered. One is possible load-voltage unbalance due to one of the phase-adapting network components being greater or smaller than its nominal rated value due to standard production tolerances. In general, the larger the I_{RL} locus as in Fig. 5, the tighter must be the tolerances of the R, L, and C components.

Another factor is the steady-state power dissipation in the phase-adapting network. Steady-state, as referred to here, means the period the motor is running at full rated rpm. From the information available in a vector diagram such as Fig. 5, this power dissipation in the phase-adapting network can be calculated.

Power dissipation P_{RL} in the Z_{RL} branch is:

$$P_{RL} = |E_{AC}||I_{RL}| \cos \theta_{RL}$$

and the power dissipation in the Z_{RC} branch is:

$$P_{RC} = |E_{CB}||I_{RC}| \cos \theta_{RC}$$

Total power dissipation in the network is the sum of P_{RL} and P_{RC}.

The power limitations of static phase adapters are essentially determined by the permissible efficiency and also the amount of phase-current unbalance which can be tolerated. Efficiency is the ratio of power delivered to the load (P) to the sum of power delivered to the load plus power dissipation in the phase adapter ($P_{RL} + P_{RC}$), or:

$$\text{Efficiency} = \frac{P}{P + (P_{RL} + P_{RC})}$$

The power dissipated in a phase adapter can vary considerably, depending upon its application and design. Efficiencies of better than 75 per cent are possible where the load is fixed and steady. If only a single phase adapter

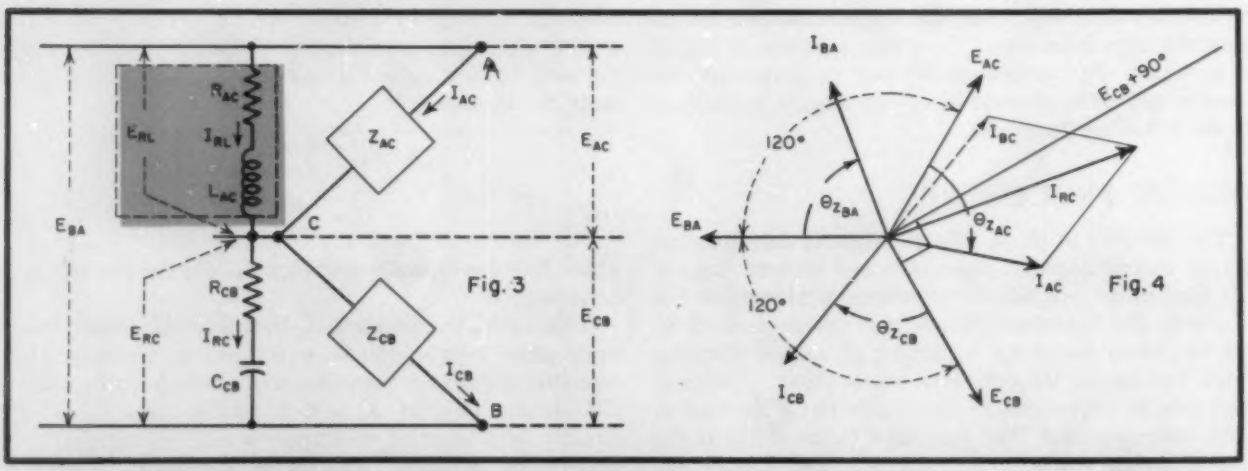


Fig. 3—Connections of phase-corrective components across phase *CB*, or across both *CB* and *AC*. Network across *CB* produces a capacitive impedance and that across *AC* an inductive impedance. No correction is required across phase *BA*. Inductive impedance is required only in cases described in text.

Fig. 4—Polar diagram showing phase-correcting current I_{RC} and limiting impedance angle of $E_{CB} + 90°$ superimposed on corrected phase voltages and currents.

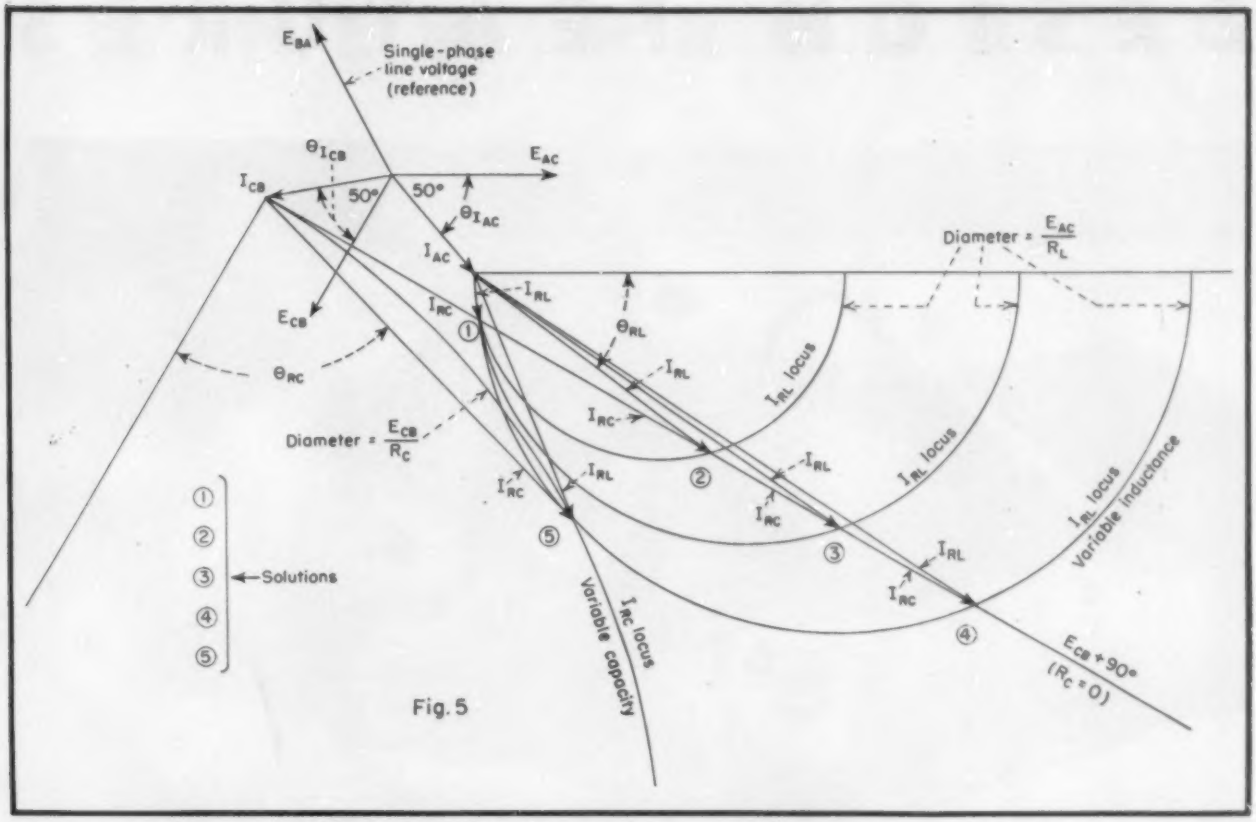


Fig. 5—Vector diagram used for graphical solution of adapter design problems. Solutions to five problems are indicated by (1), (2), (3), (4), and (5). Current vectors are drawn in accurate proportion to actual currents of phases of problem and solution is obtained by measuring vectors on graph, as described in text. For convenience principal axes of this diagram have been rotated 60 deg clockwise as compared to diagrams in Figs. 2 and 4.

network is used where induction motors are the loads, a design compromise must be made to allow reasonable motor acceleration while minimizing steady-state power loss. During a motor start greater phase voltages and resultant faster motor acceleration are realized if impedances Z_{RC} and Z_{RL} are of relatively small magnitude. As a result, induction motors can be started by high-torque producing, but low efficiency phase-adapting networks; and when motors approach full rated speed they can be switched over to a high-efficiency phase adapter for the duration of the run.

APPLICATION EXAMPLE

The problem detailed in the following steps is a typical example of phase-adapter design using a vector diagram such as Fig. 5. The solution is number four in that diagram.

Arbitrary assumptions:

$Z_{Phase} = 964 + j1145$ ohms $= 1500 \angle 50°$
Line voltage E_{AB} is 150 v, 400 cps
$\theta_{ZP} = 50$ deg
I_{AC} is drawn lagging E_{AC} by 50 deg
All currents are drawn to scale

E_{CB} is drawn lagging E_{AC} by 120 deg. I_{CB} lags E_{CB} by the angle $^{\circ}I_{CB}$ of 50 deg. From the head vector I_{CB} the line $E_{CB} + 90°$ is drawn perpendicular to E_{CB}.

Solution four lies on the line $E_{CB} + 90°$, therefore the resistance (R_C) in the capacitive network is zero.

$$I_{RL} \text{ measures } 0.325 \angle -37° \text{ amp}$$

$$Z_{RL} = \frac{E_{AC}}{I_{RL}} = \frac{150 \angle 0°}{0.325 \angle -37°}$$

$$= 462 \angle +37 \text{ ohms} = 369 + j278 \text{ ohms}$$

$$R_L = 369 \text{ ohms}, \qquad X_L = 278 \text{ ohms}$$

$$L = \frac{X_L}{2\pi f} = \frac{278}{(2)(3.14)(400)} = 0.1105 \text{ henry}$$

$$I_{RC} \text{ measures } 0.491 \angle (-120° + 90°) = 0.491 \angle -30° \text{ amp}$$

$$Z_{RC} = X_C = \frac{E_{CB}}{I_{RC}} = \frac{150 \angle -120°}{0.491 \angle -30°}$$

$$= 306 \angle -90° \text{ ohms}$$

$$C = \frac{1}{2\pi f X_C} = \frac{1}{(2)(3.14)(400)(306)} = 1.3 \text{ mfd}$$

Power dissipation in the phase adapter is determined by adding the power losses of the resistor in the capacitive network to that of the resistor in the inductive network. In this example there is no resistor in the capacitive side. Therefore,

$$R_C = 0 \text{ ohms} \qquad P_{RC} = 0 \text{ watts}$$

$$P_{RL} = |E_{AC}| \cdot |I_{RL}| \cdot \cos \theta_{RL}$$

$$= (150)(0.325)(0.8) = 39.1 \text{ watts}$$

THIS MACHINE DUPLICATES the sewing operations involved in hand stitching by passing a "floating" needle all the way through and returning it by another path.

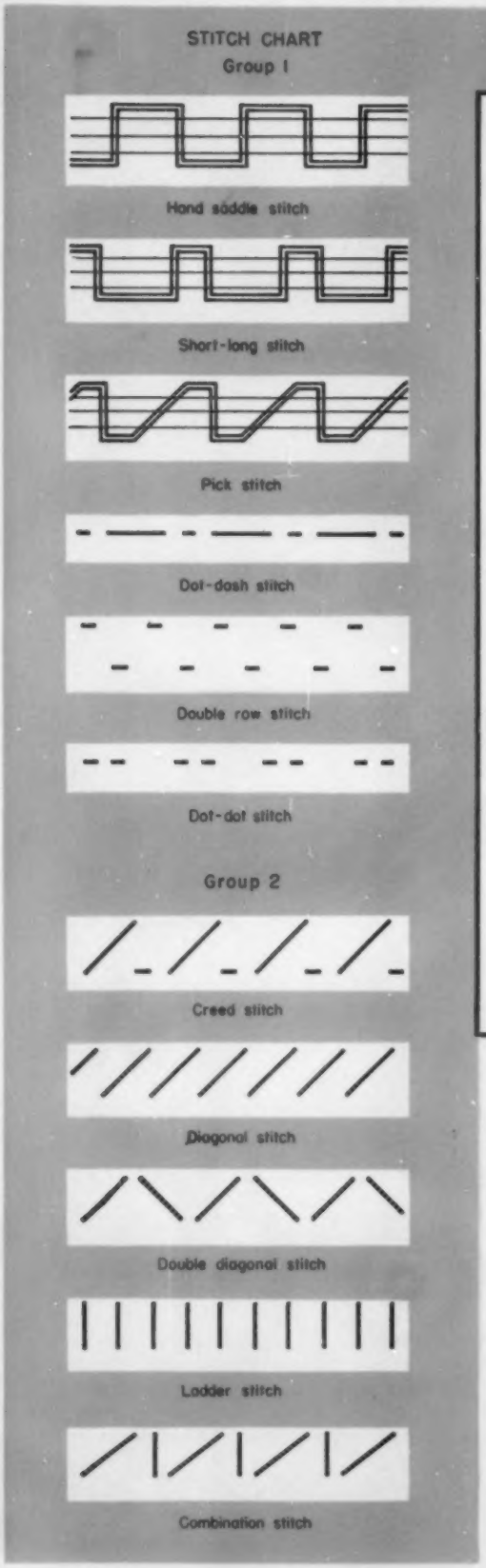
Design refinements make possible operation of 400 stitches a minute. Mechanical developments give machine capacity to produce a wide variety of stitches.

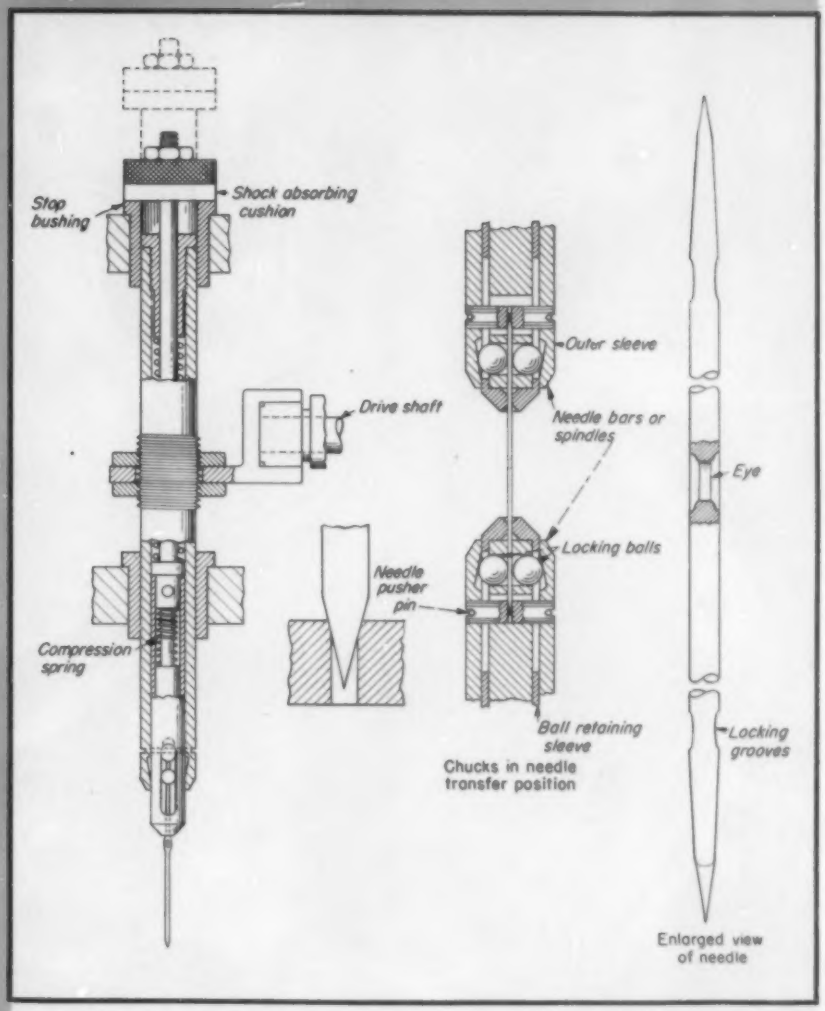
Stitching Machine Uses Free Needle

Needle trades in this country have always relied on skilled hand sewers for stitching in making gloves, sportswear and clothing. In this type of stitching, layers of cloth are bound together by a thread-carrying needle which is pushed into the cloth, drawn through from the other side and returned by a different path, the thread being drawn tight. The special skills needed for fast production require long periods of training; the work itself is drudgery—of the kind that people today expect machines to do.

After trying out many different approaches, engineers at American Machine and Foundry Company, New York, N. Y., succeeded in duplicating hand needle stitches by using a free double-pointed needle with the eye in the center. The needle is grasped by an upper needle bar, pushed into the cloth, and then released as the lower needle bar grasps the needle and pulls it on through. The thread is pulled through by a looper, and after the cloth is advanced the needle is pushed up, released and grasped again by the upper needle bar. The needle is thereby passed back and forth through the cloth as in hand stitching.

IN NEW PRODUCTS





PRINCIPAL MECHANICAL COMPONENTS in the stitching mechanism are the two opposed needle bars or spindles, which push and pull the double-pointed needle and thread back and forth through the work. Critical portions of the needle are the eye, which must be well rounded and highly polished; the two pairs of locking grooves; and specially designed points. Needle is chucked between two locking balls which are forced into the needle grooves by the conical surface of outer sleeve. This pressure is applied by the compression spring acting against ball retaining sleeve. Needle is pushed through the work by the pusher pin which bears on the angular portion of the needle just above the point. Pusher pin (shown enlarged) is designed to protect the sharp needle point. In transferring needle from upper to lower chuck, lower spindle is in uppermost position with chuck open to receive needle. As upper spindle descends with needle clamped in position, collar attached to ball retainer sleeve extension strikes the stop bushing, thereby withdrawing the balls and releasing the needle. Upper spindle then dwells in down position while lower spindle descends with the balls locked in needle grooves, thus pulling needle from the upper chuck. In transferring needle from lower spindle to upper spindle, this operation is reversed.

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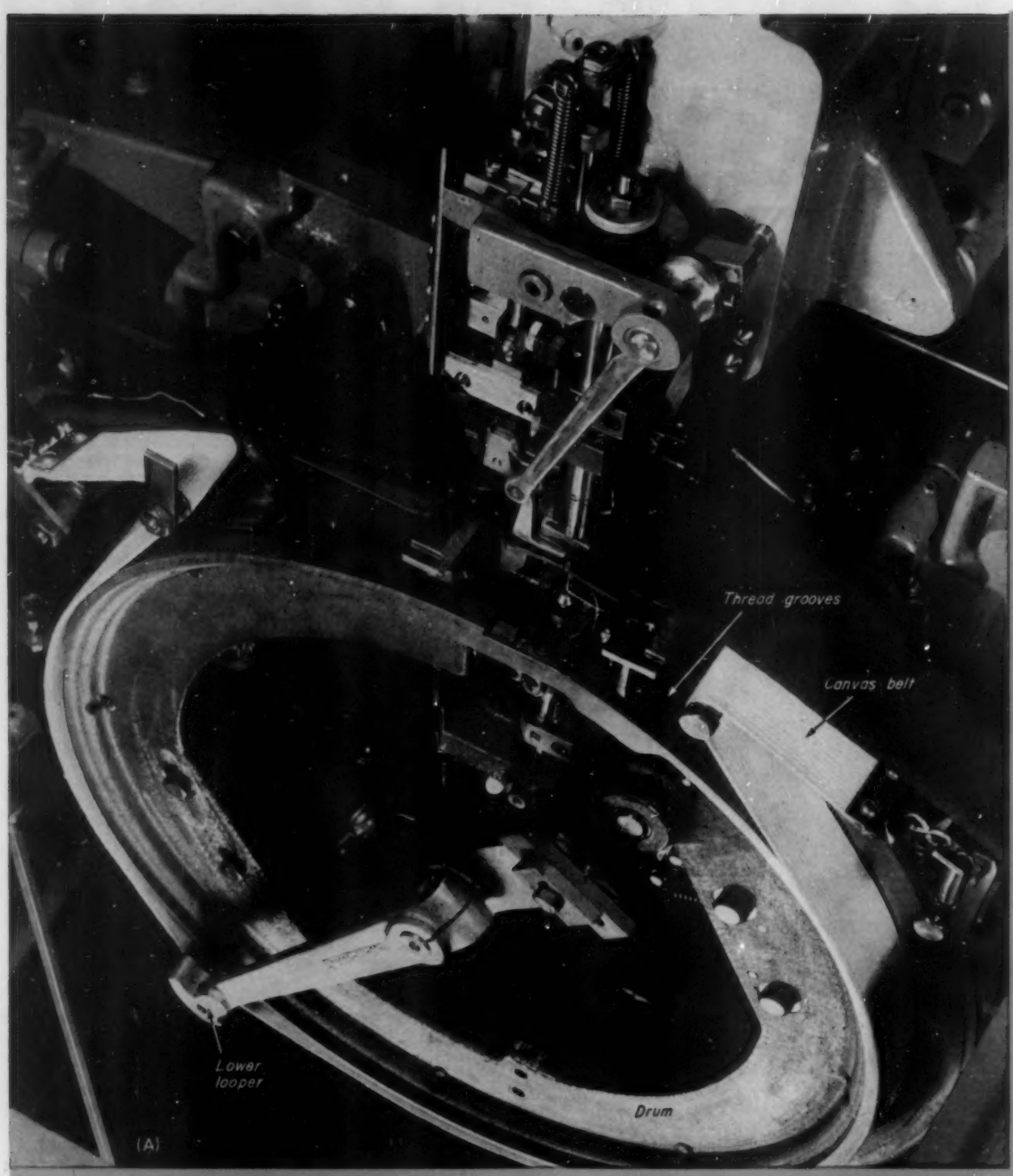
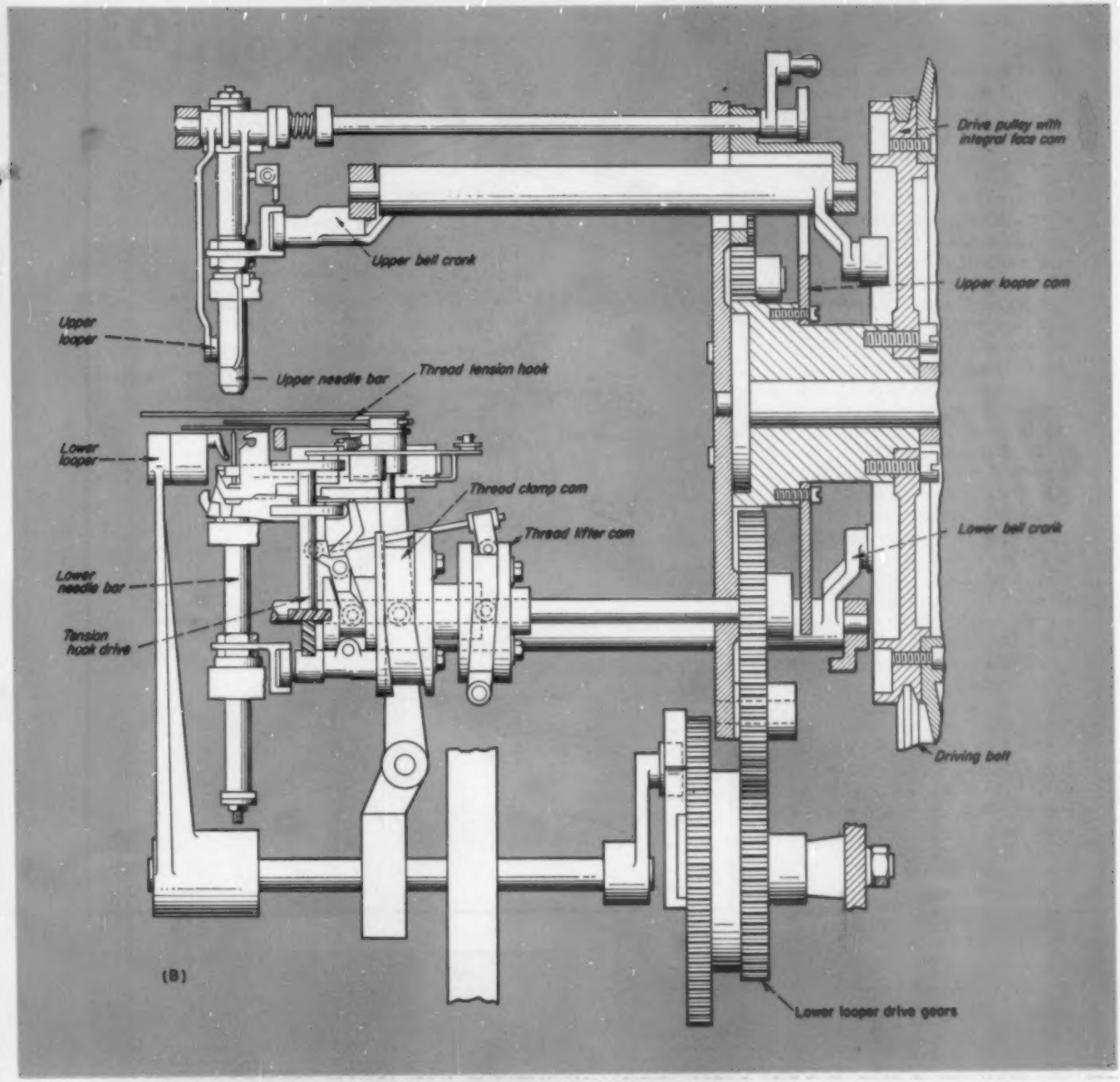
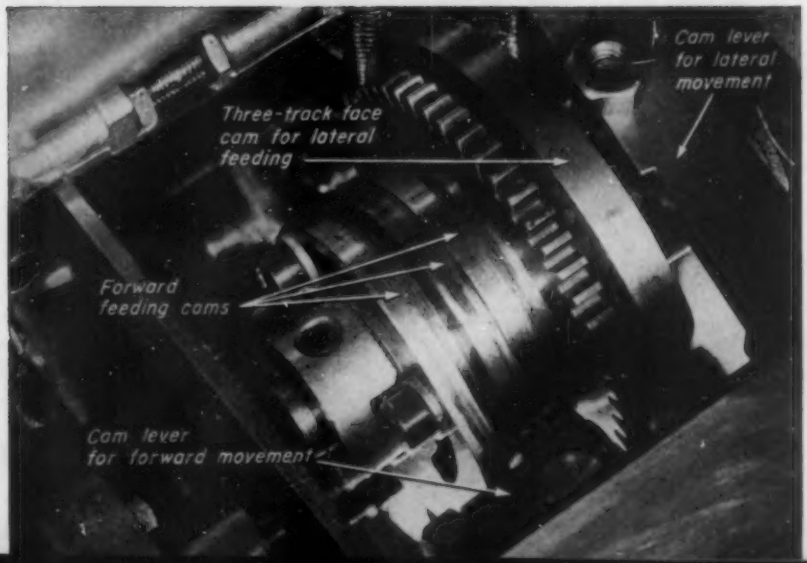


GROOVES IN OUTER FACE of drum serve as storage space for loose end of thread and the canvas belt keeps the thread wrapped around the drum as shown in (A). Alternate up and down movement of the needle bars is produced by a single face cam through upper and lower bell cranks as shown in (B). The face cam is driven by a V-belt from an electric motor through a clutch and brake which are pedal-controlled by the operator. Upper looper is rocked back and forth by the upper looper cam, which is bolted to the drive pulley. Lower looper is rotated continuously through a train of spur gears from the drive pulley; the same train of gears operates the various cams that serve to control the thread tension hook, thread lifter, and the thread clamp fingers.

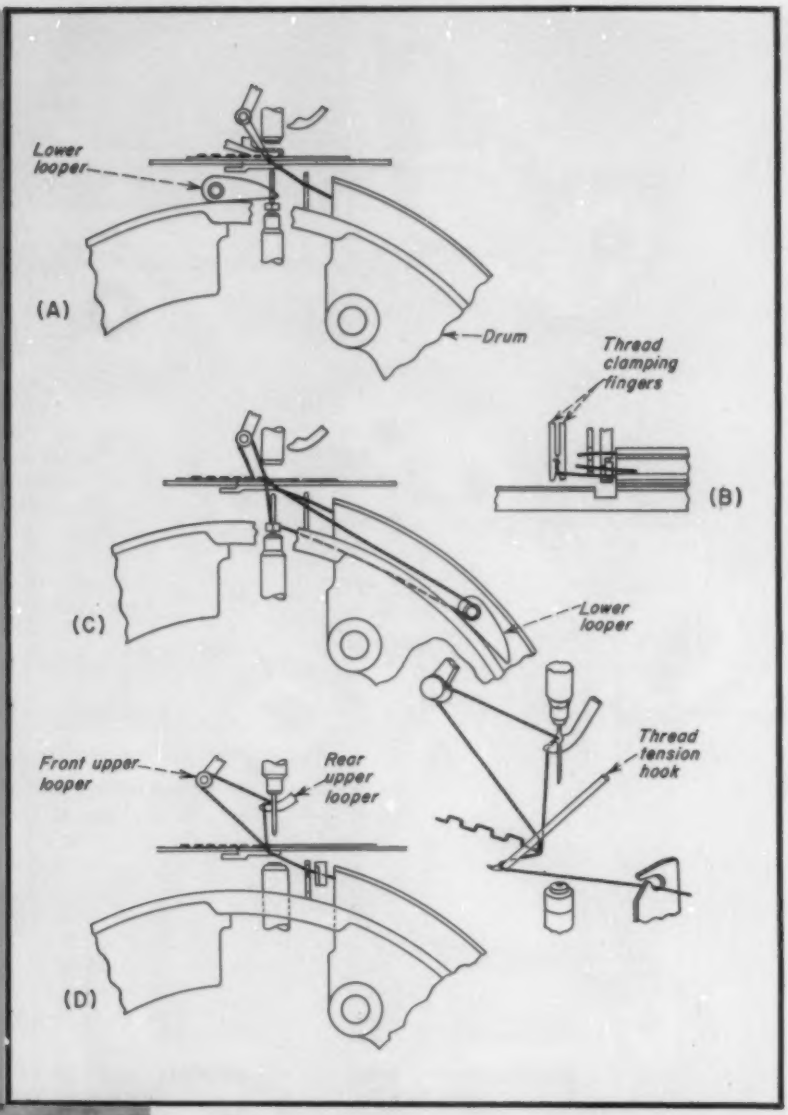


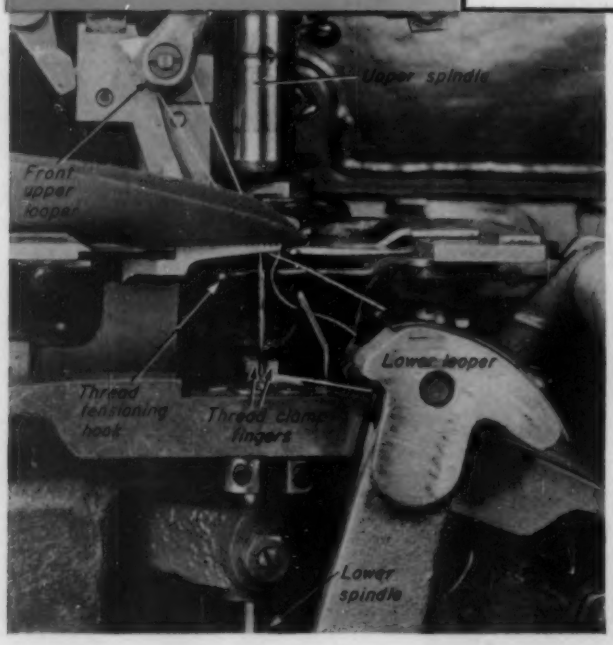

Cam lever for lateral movement
Three-track face cam for lateral feeding
Forward feeding cams
Cam lever for forward movement

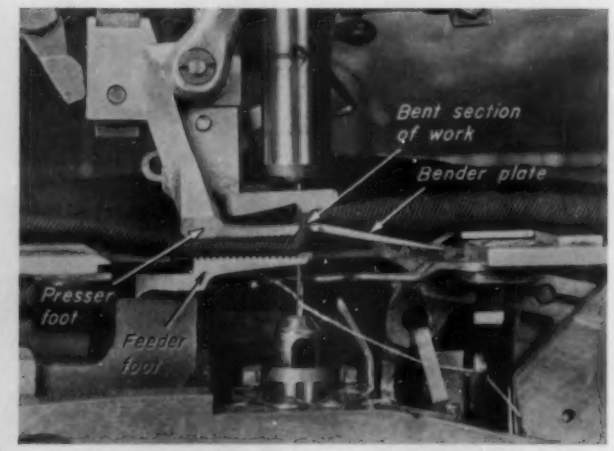
STITCHES shown in Group 2 of Stitch Chart are formed by a combination of forward and lateral movements of work. Shifting of forward and lateral cam levers causes cam followers to translate desired motions to feeder and presser feet which clamp the work and move it into position between chucks.

(continued on next page)

BASIC STITCHING CYCLE consists of one downward and one upward stroke of the needle in the course of forming a top and bottom stitch. After operator has threaded needle with threading hook attached to frame, upper spindle moves down, pushing needle and thread part way through the work. After gripping needle, lower chuck descends to complete the downward stroke of the needle (A). At this point, long free end of thread remains loose on machine table. Lower spindle then rises slightly to form a loop between needle eye and work. Rear portion of loop is held by clamping fingers (B); front portion of loop is picked up by lower looper. As this looper rotates around the drum, it pulls the free end of the thread through the work and deposits it around periphery of drum (C). With thread still clamped, tension hook moves forward against portion of thread between work and clamp fingers to tighten stitch to predetermined tension. Work is now moved forward one stitch length, whereupon lower spindle ascends, pushing needle partly through work. Needle is then gripped in upper chuck which moves upward to complete ascending stroke of needle. Next, the upper spindle descends slightly to form another loop in the thread which is picked up by front and rear upper loopers to keep thread clear of needle path (D). Work is then advanced another stitch length, and machine is ready to start another cycle.



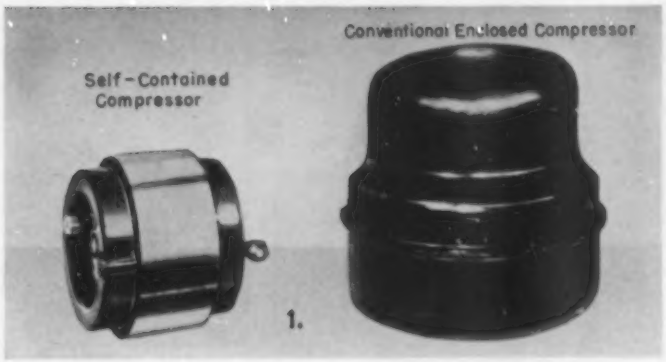




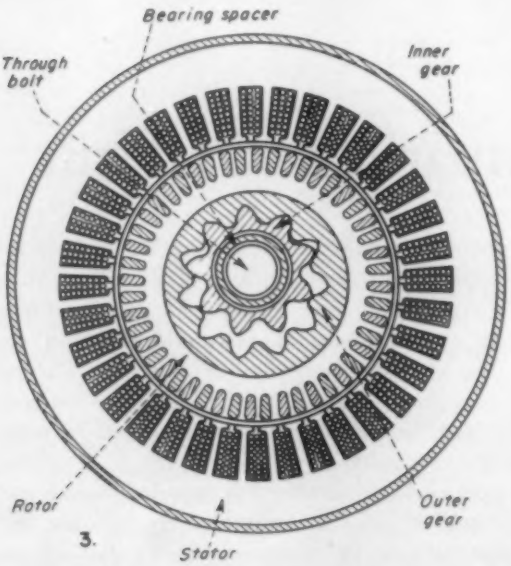
TO FORM identical pick stitches on both side of the work (see Stitch Chart), the angular portion of stitch is formed by bending the work, thereby placing a longer section of the work in the path of the needle. When work is flattened out, thread passes through the work at angle as shown in Stitch Chart.

Compact Motor Compressor

A ½-hp motor compressor unit one-fourth the size of conventional models has been designed through the joint work of Wetmore Hodges and Associates (Redwood City, California) and the Shell Chemical Corporation. The self-contained motor-driven compressor offers a better than fifty per cent weight reduction, and requires only twelve parts. The compressor mechanism is placed inside the motor. Two gears form pressure chambers to provide a positive displacement pumping action. The pump package is enclosed in the stator bore. The unit is primarily intended for use in refrigeration and air conditioning, but may also serve as a motor-pump for liquid fuel.

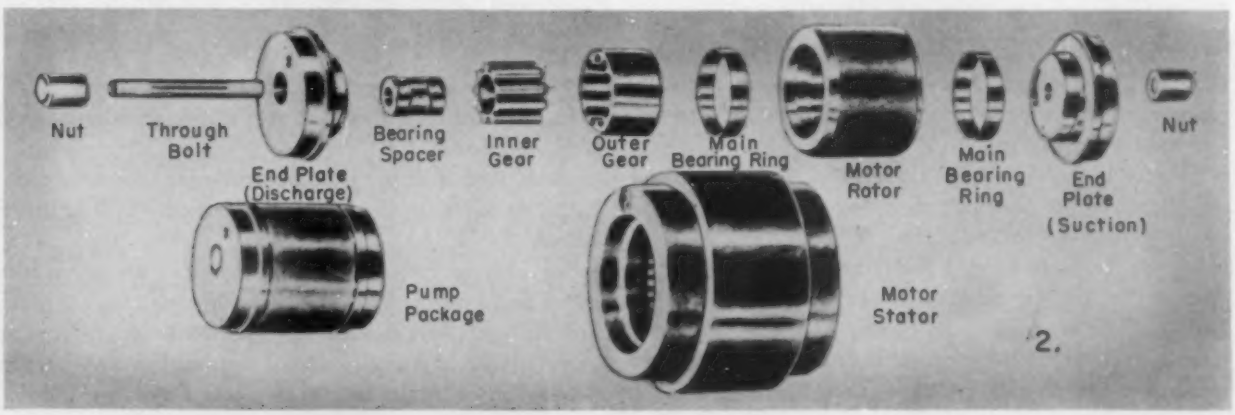


1. Epon resin is used to enclose and seal the stator windings, to permit the stator to function as a fluid-tight pressure vessel. The structure is leak-tight up to 350 psi at temperatures from —20 F to 250 F. Sufficient elasticity is provided to follow thermal changes in the iron-copper structure, with chemical shrinkage eliminated. Mechanical strength and desirable dielectric properties are indicated. Conventional hermetic enclosure at right has approximately four times the volume of the new self-contained unit.

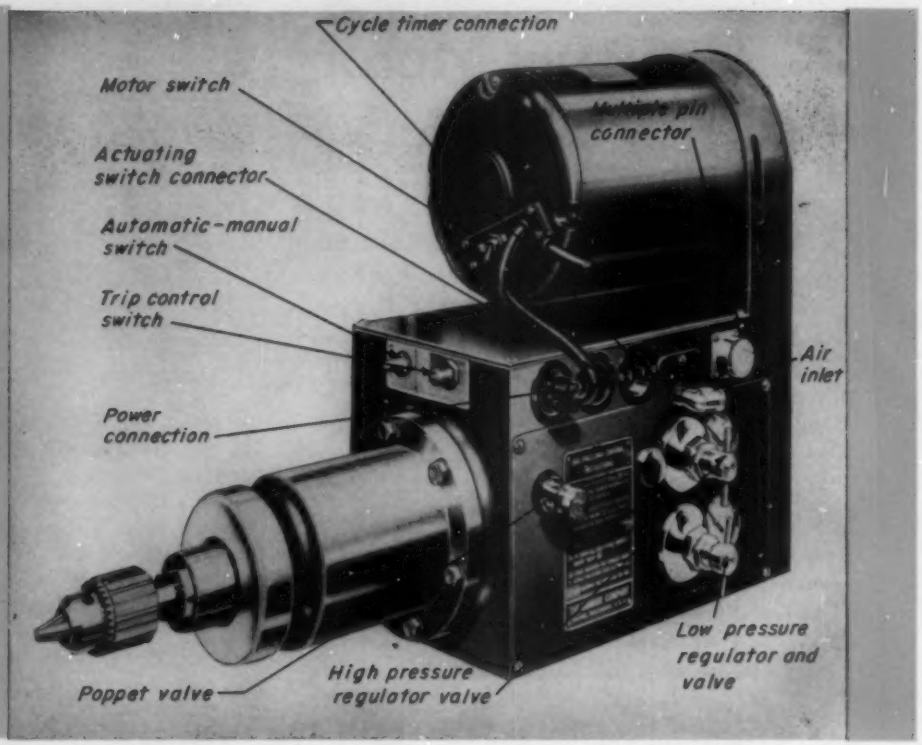


2. The self-contained compressor has only two moving parts and no valves, yet serves as a positive displacement compressor having a true compression stroke. The through-bolt furnishes the only support member of the pump package. Two nuts secure the compressor parts and receive a hermetic seal. The outer gear, bearing rings and rotor rotate as one sub-assembly. The minor periphery surface of the end-plates engage the bearing rings to rotationally position the outer gear. The inner idler gear is supported on the bearing-spacer. The outer gear transmits the rotor torque to the inner gear through an 11-to-9 tooth ratio. An inner gear tooth entering an outer gear space serves to acts as a piston. Teeth mesh to form a rotating, enclosed and isolated cavity, to produce a positive displacement. Continuous traveling contact between mating teeth is maintained through a 240-deg arc, established 120 deg before and broken 120 deg after full mesh. The effect is that of a rotating eleven-cylinder compressor.

3. The two gears and rotor rotate about true axes, and represent symmetrical configurations. No dynamic balance is required to eliminate vibration. The rotor-to-stator air gap is slightly less than half the usual clearance for a standard motor. The resistance to rotation of the idler gear is directly proportionate to the compression ratio. The bearing-spacer, besides supporting the inner gear, acts to space and align the end plates. The spacer is slightly longer than the gears, and thereby provides a fixed positive running clearance between gears and end-plates. Displacement of the unit is 1.5 cu ft per min.



AUTOMATIC drill unit has air-powered traverse with built-in pneumatic and electrical controls for production machining jobs including drilling, tapping and reaming. Unit has 3 in. stroke, adjustable within ±0.001 in., a rapid approach rate and pneumatic feed rate up to 600 in. per min and hydraulic-controlled feed rate up to 60 in. per min. Retract rate is up to 300 in. per min. Uuit is capable of maximum thrust of 400 lb at 100 psi line pressure.



Automatic Electro-Pneumatic Drill Unit

A pneumatic drill unit capable of automatic activation of transfer equipment and indexing fixtures and suitable for multiple-unit use has been developed by the Dumore Co., Racine, Wisconsin. All manual and automatic controls are built-in; the unit offers ten spindle speeds and operates on low volume air supply. Optional equipment include a hydraulic feed control for rapid advance and controlled feed, and a repeat cycle timer to facilitate chip clearance in deep hole machining.

An auxiliary circuit control of two limit switches synchronizes traverse stroke with connected devices to permit multiple unit coupling for sequence or combined operation. Multiple-pin electrical connector provides plug-in contact. Drill units may be operated in any group number with the use of a master actuating switch and master control relay.

The unit is equipped with a cogged timing belt and eight interchangeable pulleys, giving ten spindle speeds ranging from 400 to 7420 rpm.

The drill operates using about half of the air supply usually required by units of similar thrust capacity. A high-pressure air-feed valve permits adjusting the feed from zero to 600 in. per min without requiring a change in the pressure regulator setting.

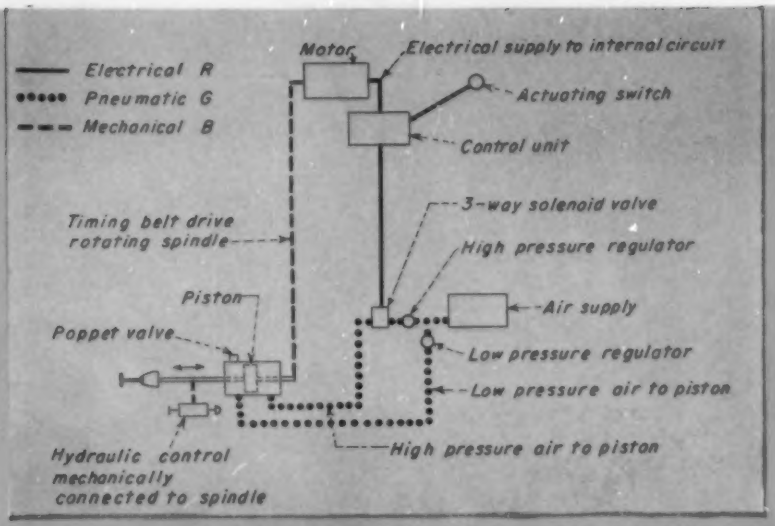
The optional hydraulic unit is mountable in the main housing. On installation, manual adjustment of a valve screw regulates forward speed, and alignment of a stop collar gives amount of pre-travel or rapid approach. The entire 3 in. stroke or any final portion may be controlled. Possibility of oil leakage between pneumatic and hydraulic systems is prevented by separation of the two units.

The repeat cycle timer effects automatic advance and retract cycling of the unit by alternately opening and closing the solenoid valve circuit. Timer dial adjustments determine the intervals of tool advance and retraction. One repeat cycle timer can control up to eight drill units.

Mounting a conventional self-reversing tapping head on a quill converts the drill unit into an automatic tapping machine.

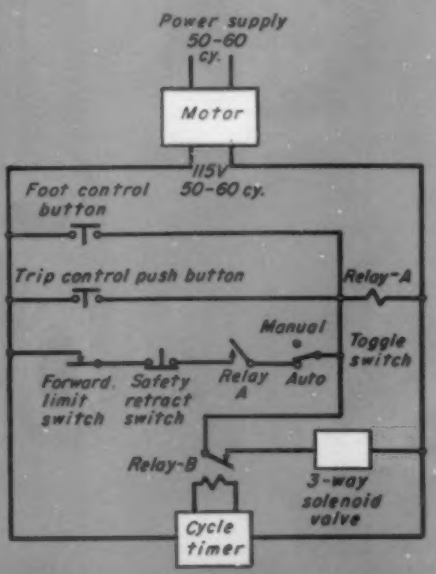
Thus, with no need to transfer the job to another machine, multiple operation may be accomplished with one set-up.

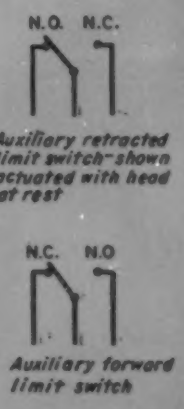
An original nose mounting bracket simplifies the mounting of the drill unit. Tooling and fixture costs are reduced, as brackets may be used on column or table and at any angle. Mounting bracket may be left on fixture, to minimize return set-up time.

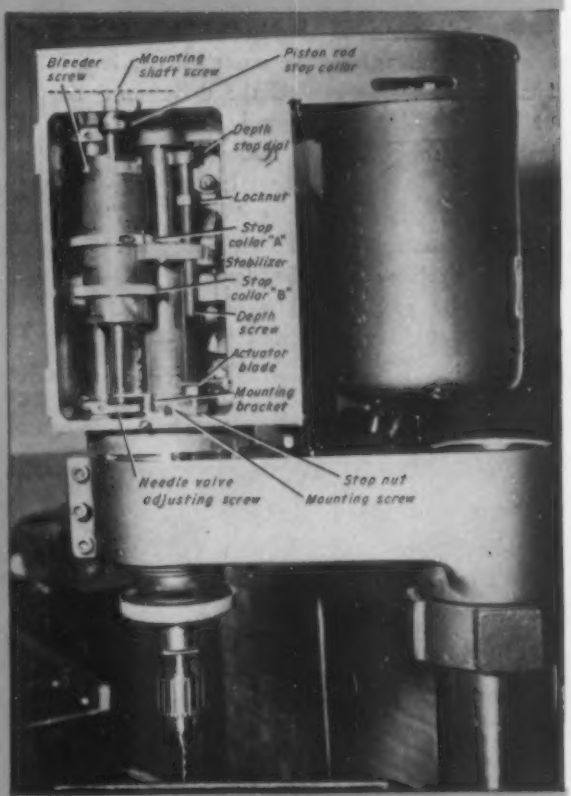


FUNCTIONAL DIAGRAM of automatic drill unit system. A ½ hp induction motor transmits rotation to cutting tool through timing belt, cogged pulleys and quill. Air is supplied to two regulators—one for power feed and one for low pressure air. Low pressure air acts as a constant force against the return side of piston, to cushion forward stroke and automatically retract piston on completion of forward stroke. Timing of air action on forward piston face is controlled by solenoid air valve. Poppet valve releases low pressure air during the advance stroke.

SCHEMATIC WIRING DIAGRAM of drill unit. With toggle switch open, unit is set for manual operation. Engaging foot or trip control button allows current flow through normally closed contacts of relay *B* and through coil of relay A. Relay A normally open contacts are closed and air valve solenoid energized, advancing piston until control button is disengaged. Release of button returns unit to retract position. With toggle switch closed, as shown, unit is in automatic operation. Momenatry contact of control button initiates current flow closing contacts of relay A, and circuit is completed through toggle switch and forward limit switch. On end of forward stroke, the limit switch breaks circuit, de-energizing coil to close valve. When repeat cycle timer is used, normally closed contacts of relay *B* are intermittently opened and closed at intervals determined by control timer settings. Opening of normally closed contacts of relay *B* breaks circuit of solenoids. Safety retract switch will operate at any stage of forward movement to give immediate return to retract position. In multiple unit operation, built-in auxiliary limit switches, wired to the multiple connector, actuate coupled units.



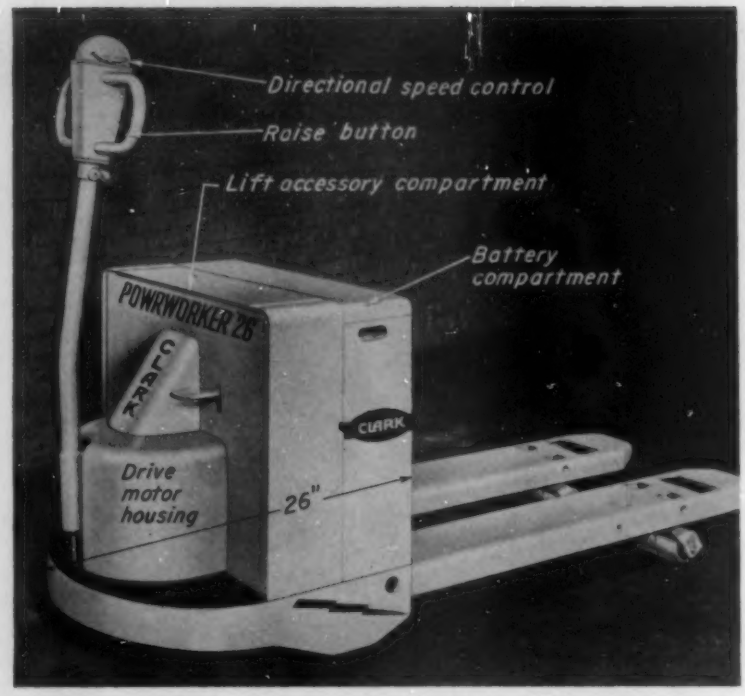




HYDRAULIC FEED control is held in place by bracket at bottom of shaft and mounting screw at top of shaft. Rotational adjustment of needle valve screw controls the oil flow (rate of forward speed). The stop collar A is adjusted so the distance between inner surfaces of both rings—less thickness of the stabilizer—equals the desired amount of pre-travel or rapid approach. Approximate length of stroke is equal to air gap between end of depth screw and flat actuator blade.

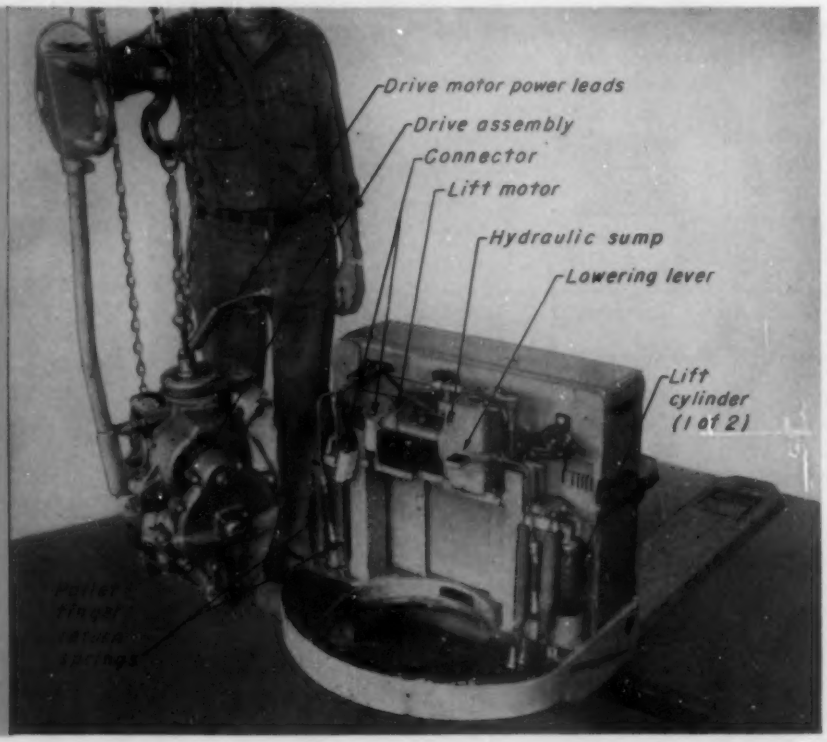
Economical Hand Truck Assembly

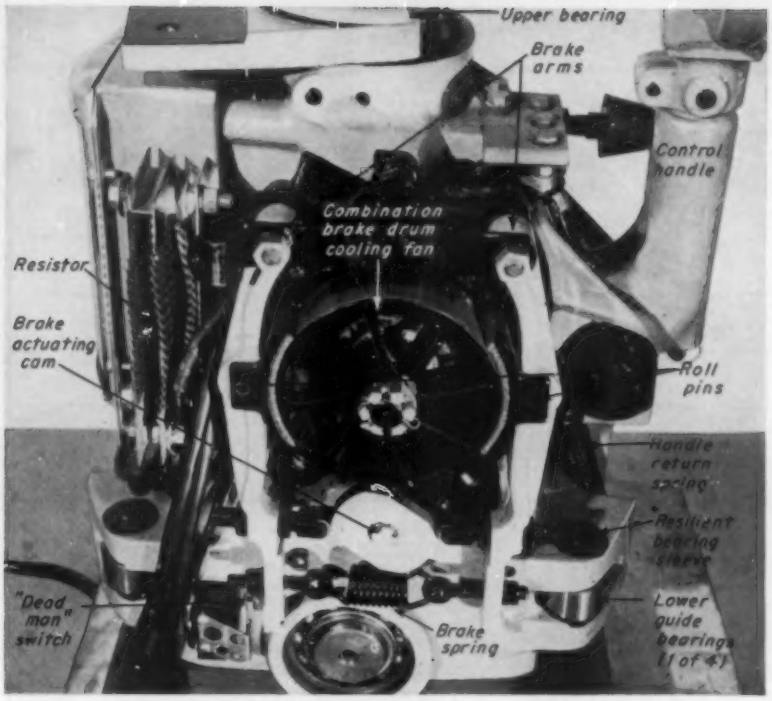
In the design of their Powrworker 26 hand truck, the Clark Equipment Company, Battle Creek, Mich., has produced a unit only 26 in. longer than the load, one of the shortest standard materials-handling trucks on the market. Primarily responsible for the new compact design is the relocation of the lift mechanism which straddles the drive unit; usually it has been installed behind the drive unit or battery. All power and control assemblies are housed in removable compartments; the drive wheel is easily demountable. For safety, a "dead man" switch automatically breaks the power circuit on release of control lever or steering handle pressure. The 4½ in. floor clearance guards against foot injury.



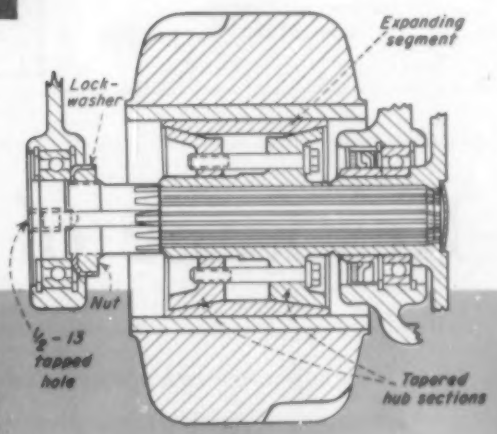
FRAME is fabricated from plate and bar steel, formed to shape and electrically welded into a unit combining light weight with strength and rigidity. Load stability is improved by mounting the battery in an underslung position close to the floor, and using a drive wheel 10½ in. dia by 6 in. wide. The tubular bayonet-type control handle and control box is a welded assembly mounted to the steering handle. A spring-loaded finger tip walking beam in the control box serves to select speed and direction. Contactors with single-break, silver-to-silver contacts are enclosed in a sealed box.

THE HYDRAULIC sub-assembly—the motor, pump, oil reservoir, valve assembly and lift cylinders—is accessible on removing the four bolts holding the one-piece cover. Equally easy access is provided for the drive motor, brakes, resistor and control panel. Revolving head permits servicing the power unit from all sides. For complete overhaul the power head, control handle and drive mechanism can be hoisted as shown, after removal of three bolts. The springs which retract the pallet finger rollers have been moved out from under the forks to protect against spring damage and corrosion and placed parallel to lift cylinders for added capacity. Electric connector between battery and motor has back-up springs for uniform tip contact pressure.

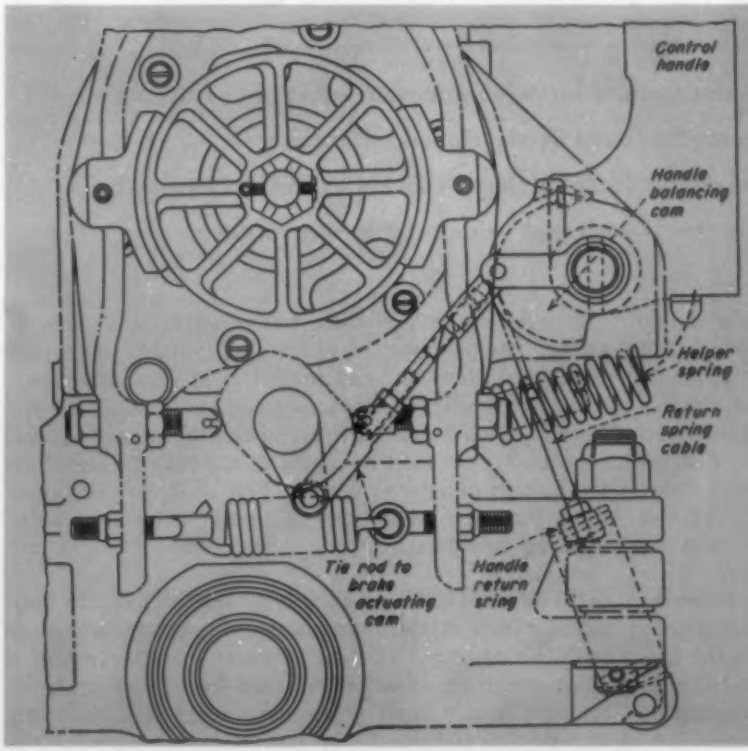




THE DRIVE MOTOR is series wound, high-torque type, ball bearing equipped and horizontally mounted. It is geared directly to the drive wheel axle through a double-reduction spur gears. A motor cooling fan is formed by the spokes in the brake drum. The drive unit is supported in the truck frame by self-aligning thust bearing and radial roller bearings. The brake operates on the motor shaft and is spring actuated. A controlled pressure is released by a cam linked to the control handle. Brake lining is bonded to a die-cast shoe. Roll pins are used instead of cotter pins because of greater shear strength. At linkage points, steel-backed graphited bronze bushings are used to eliminate grease fittings. Wiring between control and motors is direct to the power source, decreasing the voltage drop—a significant factor in a 12-volt system. To subject the wiring to as little movement as possible, leads are brought through the center of the drive spindle.



(RIGHT) A standard press-on type tire can be demounted from the wheel with hand tools. Loosening a spanner nut permits removal of the axle shaft enabling the wheel to drop out. A split wheel rim with spreader inserts makes possible immediate tire disassembly and reassembly.



(LEFT) Control handle linkage is designed so a substantially constant force carries the handle from the vertical through horizontal position. A handle-return spring working on a handle-balaucing cam offsets increased moment arm. The brake actuating cam releases pressure on the shoe and extends the brake spring. Brake is applied when handle is either in the horizontal or vertical position. The helper spring automatically snaps the handle to the vertical on release of handle pressure.

Fig. 1 — Each of these three curves represents a periodic type of force-function. Using the super position method, the motion equations for any combination of these, or even more complex functions can be solved

Fig. 2 — Typical force-function of polynomial type, $F(t) = t^3 - 10t^2 + 27t - 18$, which can also be solved simply using superposition.

WALTER W. SOROKA
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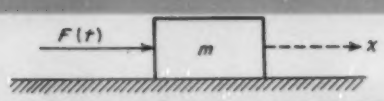
Berkeley, Calif.

Table 1—Response From Rest of Undamped, Unsprung Mass



$F(t)$	A_1	A_2	$f(t)$
a_0	0	0	$a_0 t^2/(2m)$
$a_1 t$	0	0	$a_1 t^3/(6m)$
$a_2 t^2$	0	0	$a_2 t^4/(12m)$
$a_3 t^3$	0	0	$a_3 t^5/(20m)$
$a_4 t^4$	0	0	$a_4 t^6/(30m)$
$a_5 t^5$	0	0	$a_5 t^7/(42m)$
$a_6 t^6$	0	0	$a_6 t^8/(56m)$
...	...	...	...
$b_1 \sin\omega t$	0	$\frac{b_1}{m\omega}$	$-\frac{b_1}{m\omega^2}\sin\omega t$
$a_1 \cos\omega t$	$\frac{a_1}{m\omega^2}$	0	$-\frac{a_1}{m\omega^2}\cos\omega t$
$a_1 e^{\pm st}$	$\frac{-a_1}{ms^2}$	$\pm\frac{a_1}{ms}$	$\frac{a_1}{ms^2} e^{\pm st}$

Response of Dynamic Systems

Using superposition, a simple, tabular method for solving motion equations of dynamic systems subjected to complex force-functions is developed. Data are included for pediodic, non-periodic, and impulse-type forces acting on freely as well as elastically mounted bodies initially at rest—with and without damping present.

FORCES ACTING ON DYNAMIC SYSTEMS occur in a variety of forms often termed "periodic," "nonperiodic" and "impulse." Periodic forces may have a simple harmonic variation, for example, $F(t) = b \sin \omega t$, or more complex periodic variation, such as that given by the Fourier series $F(t) = a_o + a_1 \cos \omega t + b_1 \sin \omega t + a_2 \cos 2\omega t + b_2 \sin 2\omega t + \ldots + a_n \cos n\omega t + b_n \sin n\omega t + \ldots$ Fig. 1 shows three forcing functions of the same period T. Curve A represents $b_1 \sin \omega t$; curve B, $a_1 \cos \omega t$; and curve C, $b_1 \sin \omega t + a_2 \cos 2\omega t$. In each instance, $T = 2\pi/\omega$.

Nonperiodic forces may have forms of the following types: the power series $F(t) = a_o + a_1 t + a_2 t^2 + \ldots + a_n t^n + \ldots$; the exponential $F(t) = be^{-at}$; the trigonometric form $F(t) = b_1 \sin \omega t + b_2 \sin r\omega t$ (where r is an irrational number), etc. Fig. 2 shows a nonperiodic force given by $F(t) = t^3 - 10t^2 + 27t - 18$.

Impulse forces may consist of a single or a series of pulses. The pulse may be rectangular, sawtooth, triangular, trapezoidal, sinusoidal, exponential, or of some other form. Characteristically, these forces consist of a rapid rise followed by a rapid decrease in magnitude. The time of action is generally very short compared to the time during which the motion of interest occurs. This tends to distinguish them from the other types of forces, which may be of relatively long duration.

SUPERPOSITION. In a linear dynamic system, the individual effects of the force components acting simultaneously are additive. Thus, if response characteristics of a given system are developed for each force component, the response to any linear combination of these components may be obtained directly by superposition.

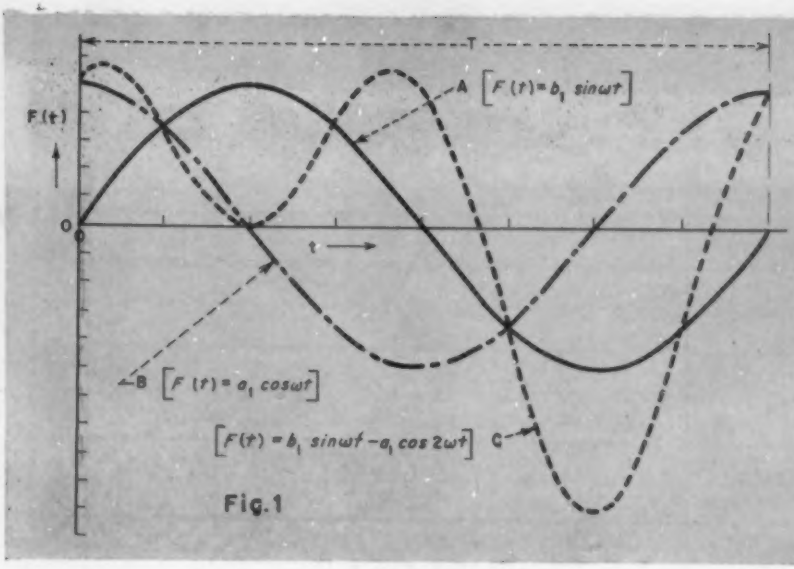


Fig. 1

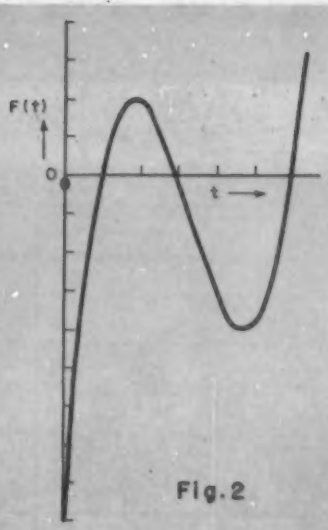


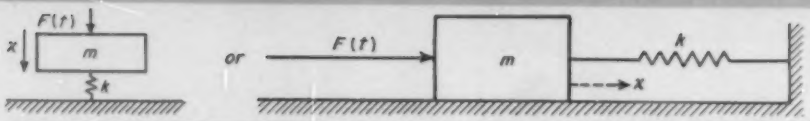
Fig. 2

Table II—Response From Rest of Damped Unsprung Mass

$$x = A_1 + A_2 e^{-\frac{c}{m}t} + f(t)$$

$F(t)$	A_1	A_2	$f(t)$
a_0	$-a_0 m/c^2$	$a_0 m/c^2$	$a_0 t/c$
$a_1 t$	$a_1 m^2/c^3$	$-a_1 m^2/c^3$	$\frac{a_1 t}{c}\left(\frac{t}{2} - \frac{m}{c}\right)$
$a_2 t^2$	$-2a_2 m^3/c^4$	$2a_2 m^3/c^4$	$\frac{a_2 t}{c}\left(\frac{t^2}{3} - \frac{mt}{c} + \frac{2m^2}{c^2}\right)$
$a_3 t^3$	$6a_3 m^4/c^5$	$-6a_3 m^4/c^5$	$\frac{a_3 t}{c}\left(\frac{t^3}{4} - \frac{mt^2}{c} + \frac{3m^2 t}{c^2} - \frac{6m^3}{c^3}\right)$
$a_4 t^4$	$-24a_4 m^5/c^6$	$24a_4 m^5/c^6$	$\frac{a_4 t}{c}\left(\frac{t^4}{5} - \frac{mt^3}{c} + \frac{4m^2 t^2}{c^2} - \frac{12m^3 t}{c^3} + \frac{24m^4}{c^4}\right)$
$a_5 t^5$	$120a_5 m^6/c^7$	$-120a_5 m^6/c^7$	$\frac{a_5 t}{c}\left(\frac{t^5}{6} - \frac{mt^4}{c} + \frac{5m^2 t^3}{c^2} - \frac{20m^3 t^2}{c^3} + \frac{60m^4 t}{c^4} - \frac{120m^5}{c^5}\right)$
$a_6 t^6$	$-720a_6 m^7/c^8$	$720a_6 m^7/c^8$	$\frac{a_6 t}{c}\left(\frac{t^6}{7} - \frac{mt^5}{c} + \frac{6m^2 t^4}{c^2} - \frac{30m^3 t^3}{c^3} + \frac{120m^4 t^2}{c^4} - \frac{360m^5 t}{c^5} + \frac{720m^6}{c^6}\right)$
• • •	• • •	• • •	• • •
$b_1 \sin\omega t$	$\frac{\omega b_1 (c^2 + m^2\omega^2)}{c\left[(m\omega^2)^2 - (c\omega)^2\right]}$	$\frac{-m^2\omega^3 b_1}{c\left[(m\omega^2)^2 - (c\omega)^2\right]}$	$\frac{-b(m\omega^2 \sin\omega t + c\omega\cos\omega t)}{(m\omega^2)^2 + (c\omega)^2}$
$a_1 \cos\omega t$	0	$\frac{a_1 m\omega^2}{(m\omega^2)^2 - (c\omega)^2}$	$\frac{a_1(c\omega \sin\omega t - m\omega^2\cos\omega t)}{(m\omega^2)^2 + (c\omega)^2}$
$a_1 e^{\pm st}$	$\mp \frac{a_1}{cs}$	$\pm \frac{ma_1}{c(ms \pm c)}$	$\frac{a_1}{s(ms \pm c)} e^{\pm st}$

Table III—Response From Rest of Undamped Mass on Spring



$x = A_1 \sin \omega_0 t + A_2 \cos \omega_0 t + f(t)$

$F(t)$	A_1	A_2	$f(t)$
a_0	0	$-a_0/k$	a_0/k
$a_1 t$	$-\frac{a_1}{\omega_0 k}$	0	$a_1 t/k$
$a_2 t^2$	0	$2ma_2/k^2$	$\frac{a_2}{k}\left(t^2 - \frac{2m}{k}\right)$
$a_3 t^3$	$\frac{6m\,a_3}{\omega_0 k^2}$	0	$\frac{a_3 t}{k}\left(t^2 - \frac{6m}{k}\right)$
$a_4 t^4$	0	$-24^2 a_4/k^3$	$\frac{a_4}{k}\left(t^4 - \frac{12mt^2}{k} + \frac{24m^2}{k^2}\right)$
$a_5 t^5$	$-\frac{120m^2 a_5}{\omega_0 k^3}$	0	$\frac{a_5 t}{k}\left(t^4 - \frac{20mt^2}{k} + \frac{120m^2}{k^2}\right)$
$a_6 t^6$	0	$720m^3 a_6/k^4$	$\frac{a_6}{k}\left(t^6 - \frac{30mt^4}{k} + \frac{360m^2 t^2}{k^2} - \frac{720m^2}{k^3}\right)$
• • •	• • •	• • •	• • •
$b_1 \sin\omega t$ $(\omega \neq \omega_0)$	$-\frac{\omega b_1}{\omega_0(k - m\omega^2)}$	0	$\frac{b_1 \sin\omega t}{k - m\omega^2}$
$b_1 \sin\omega_0 t$	$\frac{b_1}{2k}$	0	$-\frac{b_1 t \cos\omega_0 t}{2m\omega_0}$
$a_1 \cos\omega t$ $(\omega \neq \omega_0)$	0	$-\frac{a_1}{k - m\omega^2}$	$\frac{a_1 \cos\omega t}{k - m\omega^2}$
$a_1 \cos\omega_0 t$	0	0	$\frac{a_1 t \sin\omega_0 t}{2m\omega_0}$
$a_1 e^{\pm st}$	$\frac{\mp s a_1}{\omega_0(ms^2 + k)}$	$\frac{-a_1}{ms^2 + k}$	$\frac{a_1}{ms^2 + k} e^{\pm st}$

UNDAMPED, UNSPRUNG MASS. The simplest dynamic system is the undamped mass resting on a rigid support, or the free-wheeling flywheel. The equation of forced motion is $F(t) = m \frac{d^2x}{dt^2}$ for the rectilinear system, or $M(t) = I \frac{d^2\theta}{dt^2}$ for the rotational system. These equations may be solved, of course, by direct integration. The general solution is x (or θ) $= A_1 + A_2 t + f(t)$, where A_1 and A_2 are determined from the initial state of motion. Values of $f(t)$ and of A_1 and A_2 for a mass starting from rest under the action of various force components are shown in Table I. The effect of any linear combination of these forces is obtained simply by adding the solutions shown. Thus, if a force given by $F(t) = a_0 - a_4 t^4 + a_5 e^{-st} - a_2 \cos \omega t + b_3 \sin 3\omega t$ acts on a body initially at rest; from Table I the displacement-time characteristic of this mass will be:

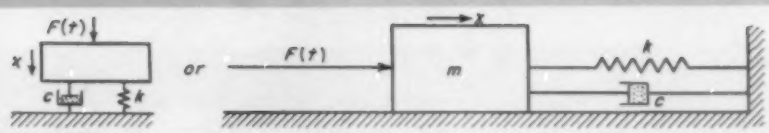
$$x = \frac{a_0 t^2}{2m} - \frac{a_4 t^6}{30m} + \frac{a_1}{sm}\left(t + \frac{e^{-st}}{s} - \frac{1}{s}\right) - \frac{a_2}{m\omega^2}(1 - \cos \omega t) + \frac{b_3}{3m\omega}\left(t - \frac{\sin 3\omega t}{3\omega}\right)$$

The velocity is obtained by differentiation:

$$\frac{dx}{dt} = \frac{a_0 t}{m} - \frac{a_4 t^5}{5m} + \frac{a_1}{sm}(1 - e^{-st}) - \frac{a_2}{m\omega} \sin \omega t + \frac{b_3}{3m\omega}(1 - \cos 3\omega t).$$

Referring to the sinusoidal forces $b_1 \sin \omega t$ and $a_1 \cos \omega t$ in Table I, it it noteworthy that although over any number of complete cycles the average force is zero, the mean dis-

Table IV—Response From Rest of Damped Mass on Spring—Light Damping



$$x = (A_1 \sin\omega_d t + A_2 \cos\omega_d t)\, e^{-\frac{c}{2m}t} + f(t)$$

$F(t)$	A_1	A_2	$f(t)$
a_0	$-\frac{ca_0}{2km\omega_d}$	$-a_0/k$	a_0/k
$a_1 t$	$\frac{a_1}{k\omega_d}\left(\frac{c^2}{2km}-1\right)$	$a_1 c/k^2$	$\frac{a_1}{k}\left(t-\frac{c}{k}\right)$
$a_2 t^2$	$\frac{a_2 c}{k^2\omega_d}\left(3-\frac{c^2}{km}\right)$	$\frac{2a_2}{k^2}\left(m-\frac{c^2}{k}\right)$	$\frac{2a_2}{k}\left(\frac{t^2}{2}-\frac{ct}{k}-\frac{m}{k}+\frac{c^2}{k^2}\right)$
$a_3 t^3$	$\frac{6a_3}{k^2\omega_d}\left(m-\frac{2c^2}{k}+\frac{c^4}{2k^2m}\right)$	$-\frac{6a_3 c}{k^3}\left(2m-\frac{c^2}{k}\right)$	$\frac{3a_3}{k}\left(\frac{t^3}{3}-\frac{ct^2}{k}-\frac{2mt}{k}+\frac{2c^2t}{k^2}+\frac{4mc}{k^2}-\frac{2c^3}{k^3}\right)$
$a_4 t^4$	$\frac{12a_4 c}{k^3\omega_d}\left(-5m+\frac{3c^2}{k}-\frac{c^4}{k^2m}\right)$	$-\frac{24a_4}{k^3}\left(m^2-\frac{3c^2m}{k}+\frac{c^4}{k^2}\right)$	$\frac{4a_4}{k}\left(\frac{t^4}{4}-\frac{ct^3}{k}-\frac{3mt^2}{k}+\frac{3c^2t^2}{k^2}+\frac{12mct}{k^2}+\frac{6m^2}{k^2}-\frac{6c^3t}{k^3}-\frac{18mc^2}{k^3}+\frac{6c^4}{k^4}\right)$
$a_5 t^5$	$\frac{120a_5}{k^3\omega_d}\left(-m^2+\frac{9mc^2}{2k}-\frac{3c^4}{k^2}-\frac{c^6}{2mk^3}\right)$	$\frac{120a_5 c}{k^4}\left(3m^2-\frac{4c^2m}{k}-\frac{c^4}{k^2}\right)$	$\frac{5a_5}{k}\left(\frac{t^5}{5}-\frac{ct^4}{k}-\frac{4mt^3}{k}+\frac{4c^2t^3}{k^2}+\frac{24cmt^2}{k^2}+\frac{24m^2t}{k^2}-\frac{12c^3t^2}{k^3}-\frac{72c^2mt}{k^3}-\frac{72cm^2}{k^3}+\frac{24c^4t}{k^4}+\frac{96c^3m}{k^4}-\frac{24c^5}{k^5}\right)$
$a_6 t^6$	$\frac{360a_6}{\omega_d k^4}\left(7cm^2-\frac{14c^3m}{k}+\frac{7c^5}{k^2}-\frac{c^7}{mk^3}\right)$	$\frac{720a_6}{k^4}\left(m^3-\frac{6c^2m^2}{k}+\frac{5c^4m}{k^2}-\frac{c^6}{k^3}\right)$	$\frac{6a_6}{k}\left(\frac{t^6}{6}-\frac{t^5c}{k}-\frac{5t^4m}{k}+\frac{5t^4c^2}{k^2}+\frac{40t^3cm}{k^2}+\frac{60t^2m^2}{k^2}-\frac{20t^3c^3}{k^3}-\frac{180t^2c^2m}{k^3}-\frac{360tcm^2}{k^3}-\frac{120m^3}{k^3}+\frac{60t^2c^4}{k^4}+\frac{480tc^3m}{k^4}+\frac{720c^2m^2}{k^4}-\frac{120tc^5}{k^5}-\frac{600c^4m}{k^5}+\frac{120c^6}{k^5}\right)$
$b_1 \sin\omega t$	$\frac{b_1\omega}{\omega_d}\left[\frac{\frac{c^2}{2m}+m\omega^2-k}{(k-m\omega^2)^2+(c\omega)^2}\right]$	$\frac{b_1 c\omega}{(k-m\omega^2)^2+(c\omega)^2}$	$\frac{b_1(k-m\omega^2)\sin\omega t - b_1 c\omega\cos\omega t}{(k-m\omega^2)^2+(c\omega)^2}$
$a_1 \cos\omega t$	$-\frac{a_1 c}{\omega_d}\left[\frac{\frac{k-m\omega^2}{2m}+\omega^2}{(k-m\omega^2)^2+(c\omega)^2}\right]$	$-\frac{a_1(k-m\omega^2)}{(k-m\omega^2)^2+(c\omega)^2}$	$\frac{a_1 c\omega\sin\omega t + a_1(k-m\omega^2)\cos\omega t}{(k-m\omega^2)^2+(c\omega)^2}$
$a_1 e^{\pm st}$	$-\frac{a_1\left(\frac{c}{2m}\pm s\right)}{\omega_d(ms^2\pm cs+k)}$	$-\frac{a_1}{ms^2\pm cs+k}$	$\frac{a_1 e^{\pm st}}{ms\pm cs+k}$

placement of the mass in the first case increases indefinitely at the rate of $b_1/m\omega$ (value of A_2). Also, the mass oscillates at a constant amplitude about this mean. For the cosine force, the mass assumes a constant mean position given by $a_1/m\omega^2$ and oscillates with constant amplitude. With both types of forces, the amplitude of oscillation falls off as the square of the forcing frequency.

DAMPED, UNSPRUNG MASS. Friction is invariably present in a dynamic system but the relationship of the frictional force to other factors in the system is, in general, highly complex. Usual practice assumes a simple linear relation between friction force and rubbing velocity, based on lubrication theory. Thus, if an oil film exists between the mass and the surface on which it moves, or, if a viscous damper connects the mass and this surface, a force $c\,\frac{dx}{dt}$ opposing the motion is developed.

The equation of motion of the damped mass then becomes $F(t) - c\,\frac{dx}{dt} = m\,\frac{d^2x}{dt^2}$. The general solution for this equation is x (or θ) $= A_1 + A_2\, e^{\frac{-c}{m}t} + f(t)$, where A_1 and A_2 are again determined from the initial state of motion of the mass. Table II gives values for

Table V—Response From Rest of Damped Mass on Spring—Critical Damping

$$x = (A_1 + A_2 t)e^{-\omega_0 t} + f(t); \omega_0 = \sqrt{k/m}$$

$F(t)$	A_1	A_2	$f(t)$
a_0	$-a_0/k$	$-\omega_0 a_0/k$	a_0/k
$a_1 t$	$-2a_1 m\omega_0$	$-3a_1/k$	$a_1(t - 2/\omega_0)/k$
$a_2 t^2$	$-6a_2 m/k^2$	$-2a_2 m\omega_0/k^2$	$\frac{2a_2}{k}\left(\frac{t^2}{2} - \frac{2t}{\omega_0} + \frac{3}{\omega_0^2}\right)$
$a_3 t^3$	$24a_3 m^2\omega_0/k^3$	$6a_3 m/k^2$	$\frac{3a_3}{k}\left(\frac{t^3}{3} - \frac{2t^2}{\omega_0} + \frac{6t}{\omega_0^2} - \frac{8}{\omega_0^3}\right)$
$a_4 t^4$	$-120a_4 m^2/k^3$	$-24a_4 m^2\omega_0/k^3$	$\frac{4a_4}{k}\left(\frac{t^4}{4} - \frac{2t^3}{\omega_0} + \frac{9t^2}{\omega_0^2} - \frac{24t}{\omega_0^3} - \frac{30}{\omega_0^4}\right)$
$a_5 t^5$	$720a_5 m^3\omega_0/k^4$	$120a_5 m^2/k^3$	$\frac{5a_5}{k}\left(\frac{t^5}{5} - \frac{2t^4}{\omega_0} + \frac{12t^3}{\omega_0^2} - \frac{48t^2}{\omega_0^3} + \frac{120t}{\omega_0^4} - \frac{144}{\omega_0^5}\right)$
$a_6 t^6$	$-5040a_6 m^3/k^4$	$-720a_6 m^3\omega_0/k^4$	$\frac{6a_6}{k}\left(\frac{t^6}{6} - \frac{2t^5}{\omega_0} + \frac{15t^4}{\omega_0^2} - \frac{80t^3}{\omega_0^3} + \frac{300t^2}{\omega_0^4} - \frac{720t}{\omega_0^5} + \frac{840}{\omega_0^6}\right)$
• • •	• • •	• • •	• • •
$b_1 \sin\omega t$	$\frac{b_1 c_c\omega}{(k - m\omega^2)^2 + (c_c\omega)^2}$	$\frac{b_1\omega(2m\omega_0^2 + m\omega^2 - k)}{(k - m\omega^2)^2 + (c_c\omega)^2}$	$\frac{b_1(k - m\omega^2)\sin\omega t - b_1 c_c\omega\cos\omega t}{(k - m\omega^2)^2 + (c_c\omega)^2}$
$a_1 \cos\omega t$	$\frac{-a_1(k - m\omega^2)}{(k - m\omega^2)^2 + (c_c\omega)^2}$	$\frac{-a_1\omega_0(k - m\omega^2) + c_c\omega^2 a_1}{(k - m\omega^2)^2 + (c_c\omega)^2}$	$\frac{a_1 c_c\omega\sin\omega t + a_1(k - m\omega^2)\cos\omega t}{(k - m\omega^2)^2 + (c_c\omega)^2}$
$a_1 e^{\pm st}$	$-\frac{a_1}{ms^2 \pm c_c s + k}$	$-\frac{a_1(\omega_0 \pm s)}{ms^2 \pm c_c s + k}$	$\frac{a_1 e^{\pm st}}{ms^2 \pm c_c s + k}$

A_1, A_2 and $f(t)$ for a viscously damped mass starting from rest. The motion of the mass under the action of any linear combination of the forces shown may be obtained by adding the tabulated solutions in the same proportions, as was done for the undamped mass.

UNDAMPED MASS ON SPRING. When the mass is attached to a flexible member or spring and damping is negligible, the equation of motion is $F(t) - kx = m\frac{d^2x}{dt^2}$ where k is the spring stiffness. The general solution of this equation is x (or θ) $= A_1 \sin\omega_0 t + A_2 \cos\omega_0 t + f(t)$, where $\omega_0 = \sqrt{k/m}$. Again, A_1 and A_2 are determined by substituting initial conditions into this and the velocity equation. Table III gives values for A_1, A_2 and $f(t)$ for a mass starting from rest under these conditions. Note that the sinusoidal forcing functions, $b_1 \sin\omega t$ and $a_1 \cos\omega t$, are divided into two parts, one comprising all frequencies different from ω_0, and one for which the forcing frequency is exactly ω_0. Different expressions for A_1, A_2 and $f(t)$ occur for these two parts. The presence of the factor t in the coefficient of the $f(t)$ term at $\omega = \omega_0$ indicates an amplitude increasing indefinitely with time.

DAMPED MASS ON SPRING. In the presence of damping, the equation of motion of the spring-mounted mass becomes $F(t) = c\frac{dx}{dt} + kx + m\frac{d^2x}{dt^2}$. The general solution assumes one of three forms, depending upon the amount of damping present. For small damping the solution is:

$$x = (A_1 \sin\omega_d t + A_2 \cos\omega_d t)\, e^{\frac{-ct}{2m}} + f(t)$$

where $\omega_d = \sqrt{\omega_0^2 - \left(\frac{c}{2m}\right)^2}$

This solution fails when $\omega_d = 0$, which occurs when $c = 2m\omega_0$. This value of c, called critical damping, is

Table VI—Response from Rest of Damped Mass on Spring—Heavy Damping

$x = A_1 e^{s_1 t} + A_2 e^{s_2 t} + f(t)$ $\qquad s_{1,2} = -\left(\frac{c}{2m}\right) \pm \sqrt{\left(\frac{c}{2m}\right)^2 - \omega_0^2}$

$F(t)$	A_1	A_2	$f(t)$
a_0	$\frac{a_0 s_2}{k(s_1 - s_2)}$	$\frac{a_0 s_1}{k(s_2 - s_1)}$	For this column use values given in Table IV
$a_1 t$	$\frac{a_1(k + cs_2)}{k^2(s_2 - s_1)}$	$\frac{a_1(k + cs_1)}{k^2(s_1 - s_2)}$	
$a_2 t^2$	$\frac{2a_2}{k^2(s_1 - s_2)}\left[s_2\left(\frac{c^2}{k} - m\right) + c\right]$	$\frac{2a_2}{k^2(s_2 - s_1)}\left[s_1\left(\frac{c^2}{k} - m\right) + c\right]$	
$a_3 t^3$	$\frac{6a_3}{k^2(s_1 - s_2)}\left[\frac{s_2}{k}\left(2mc - \frac{c^3}{k}\right) - \frac{c^2}{k} + m\right]$	$\frac{6a_3}{k^2(s_2 - s_1)}\left[\frac{s_1}{k}\left(2mc - \frac{c^3}{k}\right) - \frac{c^2}{k} + m\right]$	
$a_4 t^4$	$\frac{24a_4}{k^3(s_1 - s_2)}\left[s_2\left(m^2 - \frac{3mc^2}{k} + \frac{c^4}{k^2}\right) + \frac{c^3}{k} - 2mc\right]$	$\frac{24a_4}{k^3(s_2 - s_1)}\left[s_1\left(m^2 - \frac{3mc^2}{k} + \frac{c^4}{k^2}\right) + \frac{c^3}{k} - 2mc\right]$	
$a_5 t^5$	$\frac{120a_5}{k^3(s_1 - s_2)}\left[\frac{s_2 c}{k}\left(-3m^2 + \frac{4c^2 m}{k} - \frac{c^4}{k^2}\right) - \frac{3c^2 m}{k} + \frac{c^4}{k^2} + m^2\right]$	$\frac{120a_5}{k^3(s_2 - s_1)}\left[\frac{s_1 c}{k}\left(-3m^2 + \frac{4c^2 m}{k} - \frac{c^4}{k^2}\right) - \frac{3c^2 m}{k} + \frac{c^4}{k^2} + m^2\right]$	
$a_6 t^6$	$\frac{720a_6}{k^4(s_1 - s_2)}\left[s_2\left(-m^3 + \frac{6c^2 m^2}{k} - \frac{5c^4 m}{k^2} + \frac{c^6}{k^3}\right) - \frac{4c^3 m}{k} + \frac{c^5}{k^2} + 3cm^2\right]$	$\frac{720a_6}{k^4(s_2 - s_1)}\left[s_1\left(-m^3 + \frac{6c^2 m^2}{k} - \frac{5c^4 m}{k^2} + \frac{c^6}{k^3}\right) - \frac{4c^3 m}{k} + \frac{c^5}{k^2} + 3cm^2\right]$	
$b_1 \sin \omega t$	$\frac{\omega b_1}{s_2 - s_1} \times \frac{s_2 c + k - m\omega^2}{(k - m\omega^2)^2 + (c\omega)^2}$	$\frac{\omega b_1}{s_1 - s_2} \times \frac{s_1 c + k - m\omega^2}{(k - m\omega^2)^2 + (c\omega)^2}$	
$a_1 \cos \omega t$	$\frac{a_1}{s_1 - s_2} \times \frac{s_2(k - m\omega^2) + c\omega^2}{(k - m\omega^2)^2 + (c\omega)^2}$	$\frac{a_1}{s_2 - s_1} \times \frac{s_1(k - m\omega^2) + c\omega^2}{(k - m\omega^2)^2 + (c\omega)^2}$	
$a_1 e^{\pm st}$	$\frac{a_1(s_2 \pm s)}{(s_1 - s_2)(ms^2 \pm cs + k)}$	$\frac{a_1(s_1 \pm s)}{(s_2 - s_1)(ms^2 \pm cs + k)}$	

labeled c_c. For critical damping the general solution is:

$$x = (A_1 + A_2 t)e^{-\omega_0 t} + f(t)$$

For heavy damping ($c > c_c$), the general solution may be written: $x = A_1 e^{s_1 t} + A_2 e^{s_2 t} + f(t)$

where $s_{1,2} = -\frac{c}{2m} \pm \sqrt{\left(\frac{c}{2m}\right)^2 - \omega_0^2}$

In each instance, A_1 and A_2 are determined from initial conditions, as before. See Tables IV, V, and VI.

IMPULSE FORCES. An impulse defined by any one, or any linear combination, of the force-time relations listed in the tables will produce the corresponding motion during its time of action. When the force is abruptly cut off at time t_1, the motion then proceeds as a free motion whose initial conditions are the displacement and velocity at the cut-off time. The general expressions for the succeeding motion are those already given under the different cases above, except that the term $f(t)$ must be deleted. New values for A_1 and A_2 in the modified equations must then be found using the cut-off values of velocity and displacement. By measuring time and displacement from the cut-off point in the free motion, the calculations can be simplified.

PROTECTIVE COATINGS For Electrical Connections

Table I—Comparative Ratings of Protective Coatings for Aluminum and Copper Electrical Contacts

Type of Coating	Sealing Qualities	Adherence to Base Metal	Compatibility (See note)	Fungus Resistance	Handling Qualities	Appearance	Ease of Application	Abrasion or Chip Resistance	Oxidation Resistance at 80 C	Low Contact Resistance			
										Aluminum		Copper	
										Before Aging	After Aging	Before Aging	After Aging
Lacquers: Type 1	A	A	A	A	A	A	B	A	A	C	C	C	C
Type 2	A	A	A	A	A	A	B	A	A	C	C	C	C
Non-Drying Oil	B	A	A	A	D	C	A	A	D	A	C	A	A
Resin	B	A	A	A	B	D	B	A	B	B	C	A	B
Hot-Melt Grease	A	A	A	A	D	D	B	A	B	A	A	A	A
Solvent Grease	A	A	A	A	D	D	B	A	A	A	A	A	A
Waxes: Type 1	A	A	A	A	A	A	A	A	A	A	A	A	A
Type 2	B	A	A	A	A	A	B	A	A	A	B	A	B
Type 3	A	A	A	A	B	A	B	A	A	C	C	D	—
Chemical Passivators: Type 1	C	A	A	A	A	B	B	A	C	A	D	A	C
Type 2	C	A	A	A	B	B	B	A	D	B	D	A	C

Ratings: A—Excellent; B—Good; C—Fair; D—Unsatisfactory.

Note: Compatability with base and contact metals: Copper, aluminum, tin, silver, and cadmium.

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ALUMINUM AND COPPER BASE METAL electrical connectors and contact surfaces, when exposed to industrial or marine atmospheres without protection, grow high-resistance surface films of oxides, chlorides, or sulfides of the base metal, as shown in Fig. 1 by the darkened appearance of items *1* and *3*. The bright, oxide-free appearance of *2* and *4* are the result of protective coatings. The electrical resistance of such surface films is dependent upon thickness, which may vary from 2.7×10^{-8} to 2.3×10^{-4} in. When contacts coated with these films are used as electrical conducting areas, the high resistance produces heat which, under heavy current, may cause eventual failure of the terminal, as shown in Fig. 2 on the left.

These high-resistance films introduce a special problem on contacts not accessible for cleaning either before or during assembly, where a wiping action cannot be provided to break through the films, and where heavy currents must be conducted such as in starting, plug-stopping, and reversing of motors. In addition, the formation of these films is of concern where appearance is important.

The thickness of surface film which grows on exposed aluminum and copper surfaces is determined by the chemical and water-vapor content of the ambient air and also by the length of time which the base metals are exposed. For a six-month exposure in an industrial-marine atmos-

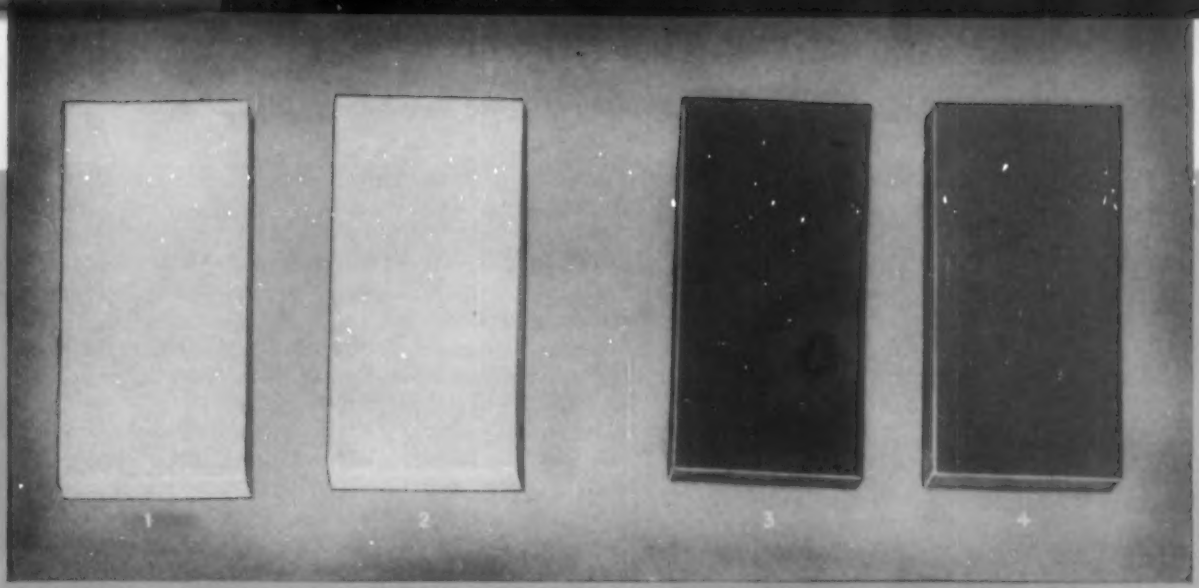


Fig. 1—Bars of aluminum (*1, 2*) and copper (*3, 4*) aged six months in industrial-marine atmosphere. Bars *1* and *3* were unprotected and are discolored with high-resistance surface films. Bars *2* and *4* were cleaned and covered with protective coating which retains bright film-free appearance.

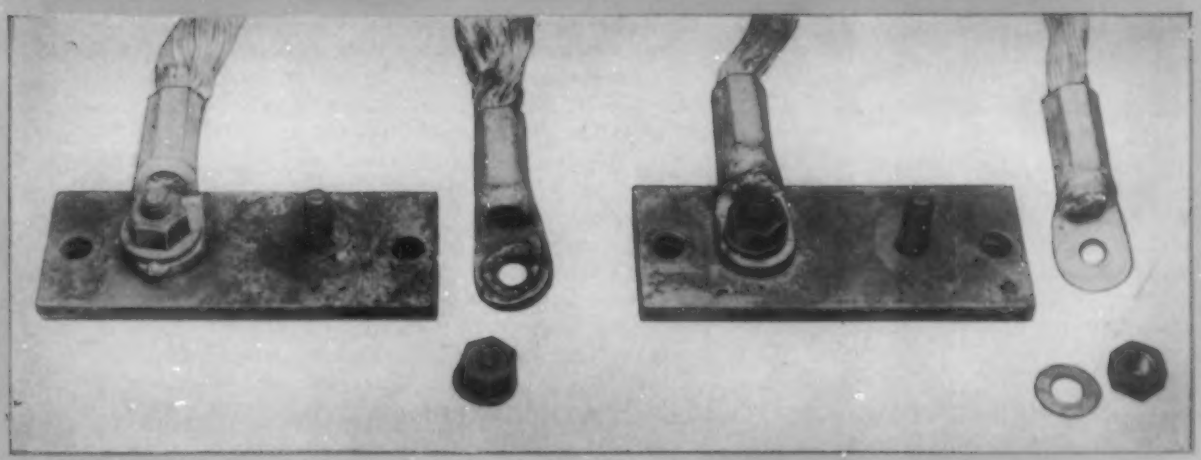


Fig. 2—Effect of high-resistance film due to exposure to atmosphere. Both samples were subject to same short-circuit current test. Surfaces of lugs on left were unprotected; surfaces of lugs on right were chemically cleaned and coated with protective compound. Resulting surface film on unprotected metal caused high-resistance electrical contact at bolted joint. Current through film produced heat which raised temperature of unprotected sample sufficiently to partially melt the lug.

For copper or aluminum connectors used on industrial equipment, low-cost coatings prevent formation of high-resistance surface films; aid in maintaining low-resistance connections and preventing discoloration.

phere, the increase in resistance of a copper film as compared to the chemically cleaned copper was in the order of 150 to 1. For aluminum under similar conditions, the increase in resistance was approximately 1500 to 1.

METHODS OF PREVENTING FILM FORMATION

Formation of these oxide, sulfide, or chloride films can be prevented by applying a protective coating which seals the metal and prevents the corrosive vapors from attacking the surface either by penetration through or creeping underneath the coating. There is a wide range of material available for use as a protective coating including: lacquers; flushing compounds in which metal parts are dipped to prevent rusting in storage; petroleum-resin compounds; greases; waxes; and chemical passivators such as an acid bath. Electroplating can also be used, but its cost is considerably higher.

COATING MATERIALS

Several coating materials are listed in Table I. The lacquers are clear nitro-cellulose with ketone solvents. Type 2 has twice as much solvent as type 1. The non-drying oil is a castor-oil base slushing compound which remains permanently oily. The resin coating is a hard-drying petroleum slushing compound with the resin added.

Table II—Cleaning & Application Procedure of Protective Coatings

A. *ALUMINUM (High Conductivity)*
1. Alkali dip-heated to 180 deg F, 1 to 3 min; cold water rinse
2. Nitric Acid dip, 2 to 5 sec; cold water rinse
3. Hot water rinse
4. Apply coating; drain
5. Centrifuge off excess coating; dry

B. *ALUMINUM (Silicon Alloys)*
Same as above except for the nitric acid dip substitute hydrofloric plus nitric acid dip of 45 sec.

C. *COPPER*
1. Alkali dip, 180 to 200 deg F, 1 to 3 min; cold water rinse
2. Sulfuric plus nitric acid dip 15 seconds; cold water rinse
3. Chromic acid dip, 15 seconds; cold water rinse
4. Cyanide solution, 15 seconds; cold water rinse.
5. Hot water rinse
6. Apply coating; drain
7. Centrifuge off excessive coating; dry

The hot-melt grease is a petroleum-wax-resin compound, while the solvent grease is crude lanolin-and-solvent mixture. The chemical passivators are chromic acid dips. Waxes include: Type 1—a paraffin microcrystalline wax blend using hot-melt dip application; type 2—a paraffin microcrystalline blend using solvent drying; and type 3—a microcrystalline wax of a polyisobutylene blend using hot-melt dip.

COATING REQUIREMENTS

Each coating, to provide suitable protection against film growth, must possess these characteristics:

Sealing Qualities. Coating should prevent penetration of water vapor *through* coating to conducting surface.

Adherence to Base Metal. Coating should resist creep of corrosion *underneath* edges.

Compatibility with Base and Contact Metals. Coating should not form high-resistant or discoloring chemical films on aluminum, copper, tin, silver, or cadmium.

Fungus Resistance. Coating should prevent fungicidal attack, as outlined in military specifications MIL-W-7072 or MIL-W-5086 for electrical conductors.

Handling Qualities. Coating (1) should not remain tacky after application and drying, and (2) should not adhere to other coated material so that coatings are ruptured when parts are separated.

Appearance. Coating should maintain the bright color of the unoxidized connector for periods of at least six months' exposure to industrial marine atmospheres.

Ease of Application. Coatings should be easy to apply using basket dip for coating and centrifuge for draining.

Abrasion Resistance. Coating should successfully resist abrasion or rupture during application, handling, or use.

Oxidation Resistance. The majority of conductors are current-rated below 80 C, due to insulation temperature limits. The protective coatings should prevent connector oxidation at a sustained temperature of 80 C.

Contact Resistance. The coating should permit a metal-to-metal contact under low pressures and produce a low contact resistance. This resistance should remain low despite aging in oxidizing atmospheres.

On the basis of these requirements, the various coating materials are evaluated in Table I. The rating of *A* indicates the coating is excellent, *B* indicates good, *C* indicates fair, while *D* is considered unsatisfactory.

COATING APPLICATION

Before applying the protective coating, a chemical bath which removes grease, dirt, and existing surface films, is necessary. The chemical action of the bath replaces the

Fig. 3 (Left)—Testing machine and test setup used to determine pressure-resistance relationships for electrical contact surfaces.

Fig. 4 (Below)—Electrical circuit for measuring resistance at various pressures.

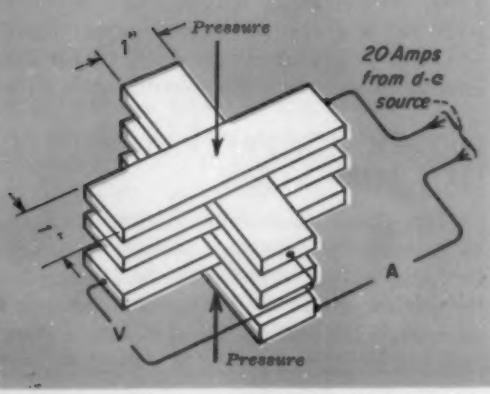


Table III—Resistance of Unprotected and Protected Aluminum and Copper Contact Surfaces.

Before and after aging 6 months in outside industrial and marine atmospheres.

Condition of Contacts or Type of Coating	Aluminum Contact Resistance, Microhms		Copper Contact Resistance, Microhms	
	Before Aging	After Aging	Before Aging	After Aging
Cleaned-Not Protected.....	35–70 (See note)	13,000–22,000	0.85–1.50 (See note)	550–750
From Stock (Not Cleaned)...	1310–2120	21,100–28,100	145–350	1200–2200
Wire Brushed Just Prior To Test.....	9–22		0.75–1.30	
Wire Brushed Under Grease..	8–12		0.80–1.25	
Lacquers: Type 1.....	198–225	259–420	52–69	70–75
Type 2.....	162–212	210–238	49–54	195–220
Non Drying Oil.....	32–45	39.72	1.75–1.92	6.20–8.91
Resin Coating.....	57–121	192–178	12.0–15.1	25.0–32.1
Hot Melt Grease.....	25.7–35.8	42.1–55.7	10.2	127
Solvent Grease.....	12.2	19.2–27.4	7.2–11.5	9.15–15.3
Waxes: Type 1.....	10.5–24.5	15.8–39.4	1.05–1.50	8.75–13.00
Type 2.....	15.2–29.4	220–252	1.15–1.75	22.5–57.2
Chemical Passivators: Type 1	48.2–51.5	520–652	2.30–2.52	45–71
Type 2	149.1–179.5	352–475	1.25–1.38	72–80

All measurements taken at contact pressure of 6000 psi. Maximum and minimum readings of five sets of bars.
Note: Aged for maximum of four hours before test.

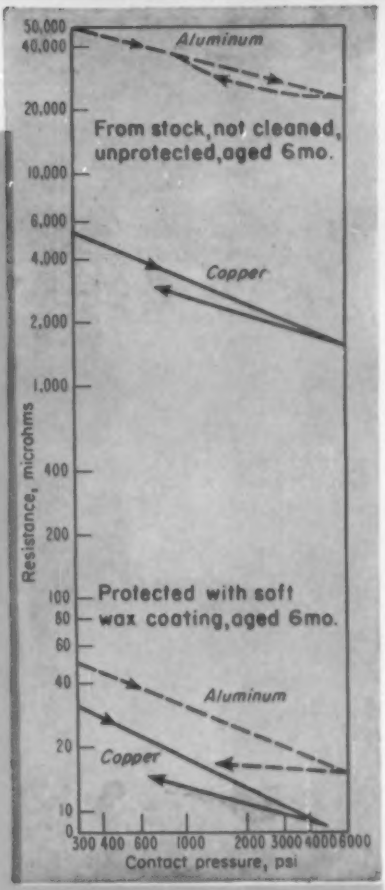


Fig. 5—Reversibility of resistance with decrease in pressure, after aging. Resistance of unprotected aluminum returns to original value, while that of unprotected copper remains at some value less than that at beginning of measurements.

films with a thin uniform film of low resistance. The cleaning procedure for high-conductivity aluminum and aluminum-silicon alloys is outlined in Table II, steps A1, A2, and A3. For copper this procedure is listed in steps C1, C2, C3, C4 and C5. Immediately following this cleaning the protective coating is applied.

TEST METHOD

To determine the value of protective coatings in producing and maintaining low-resistance contact surfaces, specimens of thin, smooth, 1-in. bars of aluminum and copper were obtained in the four following categories:

1. Bars with contact surfaces not cleaned (As taken from storage)
2. Bars with surfaces cleaned with abrasives
3. Bars with contact surfaces chemically cleaned
4. Bars with contact surfaces chemically cleaned and then covered with a protective coating following procedures in Table II.

In each of the categories sufficient specimens were provided to make up several test groups of six bars in each group. Using the test setup shown in Fig. 3 and the electrical circuit connections shown in Fig. 4, the resistance of each test group was determined at contact pressures from 300 to 6000 psi. Measurements were taken at the beginning of the test and after a six-month aging period in which the bars were exposed to outside industrial-marine atmosphere. Table III indicates the results obtained with unprotected bars and bars coated with the coatings listed in Table I. The spread in readings between the maximum and minimum values is due to measured variations in five test groups of each type of plain or coated bars.

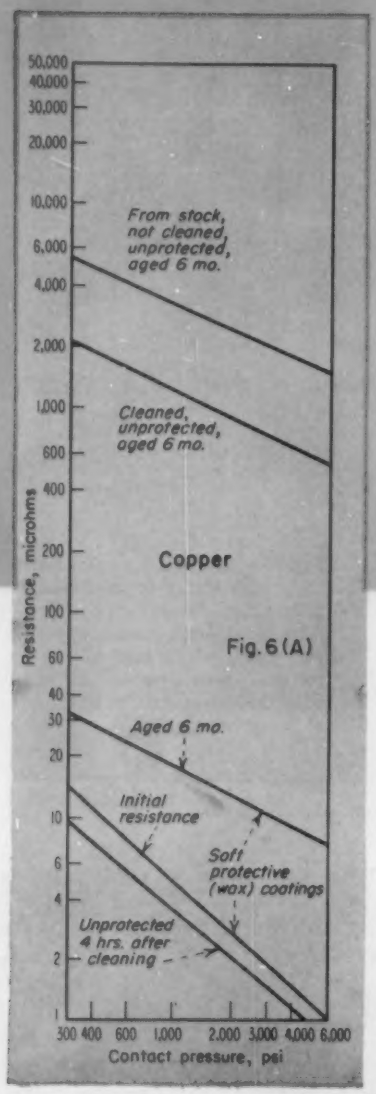
SUMMARY

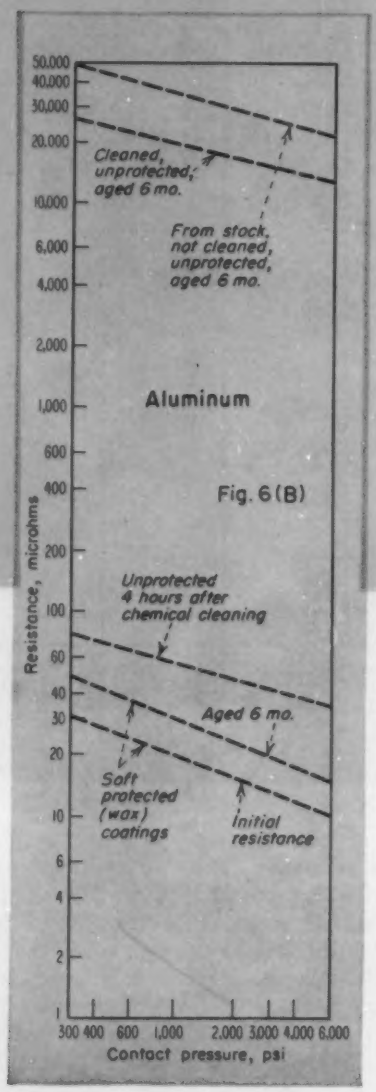
Test results indicate that as the contact pressure is increased, the resistance decreases for both coated and unprotected contact surfaces, newly cleaned or aged six months. This is indicated by all lines on the graphs of Figs. 5, 6, and 7 slanting downward to the right; resistance increases upwards along the ordinates, pressure increases to the right along the abscissas.

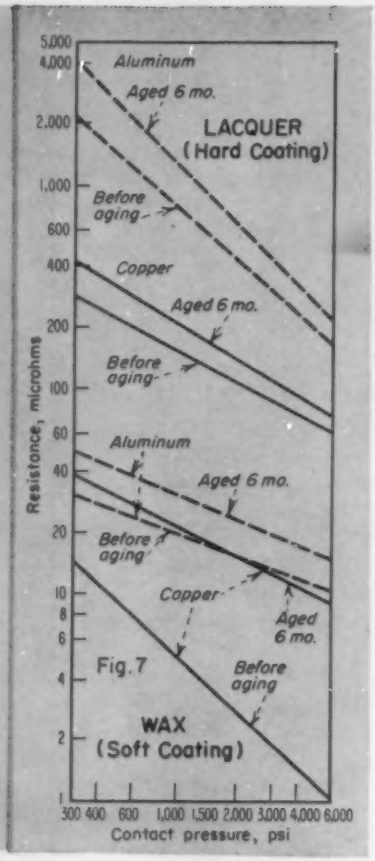
The effect of resistance reversibility, or decrease in resistance when contact pressure is reduced, is shown in Fig. 5 which compares this characteristic of both coated and uncoated aluminum and copper after aging six months.

Fig. 6—Curves showing how the protective coatings maintain the contact resistance of aluminum or copper substantially below that of the unprotected metal after six months' aging. (A) Curves show resistance of protected and unprotected copper. (B) Aging-resistance curves of protected and unprotected aluminum.

Fig. 7—Comparison of hard and soft coatings. Initial and final resistance of lacquer coating is considerably higher than that of soft microcrystalline wax. Soft wax-like coatings are penetrated more easily under low pressures.







Resistance of the coated aluminum is essentially less reversible than that of coated copper; but resistance of the unprotected aluminum returns to its original value, while that of unprotected copper remains at some value less than the original. In both cases the protective coating tends to maintain a reduced contact resistance, despite decreasing contact pressure.

The use of protective coatings maintains the contact resistance substantially below that of unprotected aluminum or copper for various contact pressures. In Fig. 6 (A) the curves show the resistance of coated and uncoated bars of copper before and after six months aging. (B) of Fig. 6 indicates similar differences between coated and unprotected aluminum. Note that the relative resistance of uncoated aluminum increases considerably only four hours after the initial acid cleaning bath.

A comparison of the effectiveness of hard and soft protective coatings is shown in Fig. 7. Both the initial and final resistance of contacts using a hard lacquer coating is considerably higher than that of a soft microcrystalline wax. For most applications the substantially lower resistance of the soft wax coating makes it most desirable to use. The softer wax-like coatings are penetrated more easily under low pressures than the hard-types. Some grease-like coatings have excellent protective qualities, but they have the disadvantage of remaining tacky and tending to collect dust and dirt.

EDITOR'S NOTE—A forthcoming article will describe the characteristics and applications of electroplating materials used for protection of electrical-connector contact surfaces. A previous article, "Compression Terminals for Aluminum Conductors", Sept. 1954, page 150, describes the use of a compound of metal powder suspended in petrolatum in providing surface-film cleaning and also protection against reformation of the film for aluminum-to-aluminum and aluminum-to-copper connections.

THEORY OF HYDRAULIC FLOW CONTROL

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In the design of any hydraulic circuit, the rate of flow is determined by the resistance of the various components and by the pressure differential across the circuit. Because, in spite of its importance, there is a serious lack of published data on hydraulic resistance, equations are derived herein for the flow rate of any circuit — including both parallel and series types. This is followed by a flow analysis of such components as valves, venturis, orifices and other flow limiting devices. Comprehensive examples illustrate the application of the analyses to practical design problems.

SYMBOLS

H = loss of head, ft
V = maximum velocity, ft/sec
g = gravitational constant, = 32.2 ft/sec²
ϵ = coefficient of energy loss of a passage
P = pressure loss, psi
S = specific gravity of fluid
G = flow rate, US gal/min
W = flow rate, lb/sec
h = potential head, ft
ν = kinematic viscosity, centistokes
μ = absolute viscosity, centipoises
p = fluid pressure, psia

$\Sigma = \sum_{i=1}^{i=n} \epsilon_i D_i^{-4}$ = sum of hydraulic resistances

$\sum_{i=1}^{i=n}$ = sum of pressure losses, psi

$\psi = \epsilon_0 D^{-4}$ = hydraulic resistance
C_D = coefficient of discharge
R = Reynolds number
f = coefficient of friction
D = dia of fluid passage, in.
Δp = pressure differential, psi

When fluid flows through a passage such as a pipe, venturi tube, flow control valve, etc., hydraulic resistance will cause a dissipation of energy in the form of heat with a resulting loss in pressure. This loss of energy can be expressed as a function of the velocity head:

$$H = \epsilon V^2/2g \tag{1}$$

The loss of head H and the pressure loss P are related by:

$$P = 0.4333\, SH \tag{2}$$

or

$$H = 2.3077\, P/S \tag{3}$$

Combining Eqs (1) and (3),

$$P = 6.729 \times 10^{-3}\, S\epsilon V^2 \tag{4}$$

In most applications, the velocity V is not known and varies throughout the system. The rate of flow, however, is generally given, either in US gpm (G) or lb per sec (W). These quantities, V, W and G are related as follows:

$$V = 0.4085\, GD^{-2} = 2.938\, WS^{-1}D^{-2} \tag{5}$$

Substituting the preceding flow relations in Eq (4), the pressure loss in any fluid passage is expressed by:

$$P = 1.123 \times 10^{-3}\, G^2 S\epsilon D^{-4} \tag{6}$$

and

$$P = 5.809 \times 10^{-2}\, W^2 S^{-1}\epsilon D^{-4} \tag{7}$$

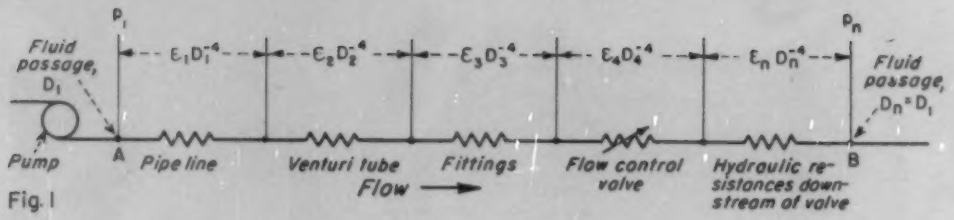


Fig. 1

Fig. 1—Basic hydraulic resistance diagram for series circuit in which pipe diameter and elevation are constant between points *A* and *B*. Eqs. (9), (10) and (11) give the pressure drop and resistance for this fundamental circuit; Eqs (18) and (19) give the flow rate.

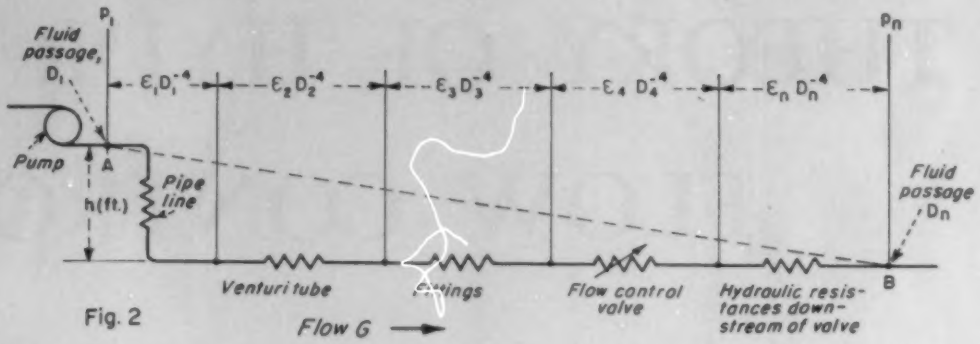


Fig. 2

Fig. 2—Resistance diagram for series circuit in which elevation and pipe diameter vary between points *A* and *B*. Eqs (14) and (15) give the pressure drop; Eqs (16) and (17) give the flow rate.

where the product ϵD^{-4} is called the hydraulic resistance, and ϵ is the coefficient of energy loss.

Because most passages are circular in cross-section, all succeeding equations will be derived in terms of diameters. In the preceding relationships D is the diameter of the smallest section of the fluid passage, where the velocity is a maximum. If the flow area A is noncircular, it can be converted into an equivalent diameter as follows:

$$D = 1.128\sqrt{A} \tag{8}$$

If in Fig. 1, the fluid passage is horizontal and has the same diameter at points A and B ($D_1 = D_n$), Eq (6), which involves volume flow-rates can be written as:

$$p_1 - p_n = \sum_{i=1}^{i=n} P_i = 1.123 \times 10^{-3} G^2 S \sum_{i=1}^{i=n} \epsilon_i D_i^{-4} \tag{9}$$

and, for mass flow-rate units, Eq 7 is

$$p_1 - p_n = \sum_{i=1}^{i=n} P_i = 5.809 \times 10^{-2} W^2 S^{-1} \sum_{i=1}^{i=n} \epsilon_i D_i^{-4} \tag{10}$$

where p_1 and p_n are the absolute pressures at A and B, respectively, and the summation of P_i is the total pressure loss, or the sum of the pressure losses in the various passages. The last term represents the sum of the various hydraulic resistances, and will be represented by the symbol Σ in all succeeding equations where:

$$\Sigma = \sum_{i=1}^{i=n} \epsilon_i D_i^{-4} = \epsilon_1 D_1^{-4} + \epsilon_2 D_2^{-4} + \epsilon_3 D_3^{-4} + \cdots \epsilon_n D_n^{-4} \tag{11}$$

If point A is located at a different elevation than B, as shown in Fig. 2, and the fluid passage at points A and B are of different diameter (D_1 and D_n), Eqs (9) and (10) must be modified to include the effect of the potential head h and the change in pressure caused by variations in velocities. The expression for the pressure differential, $p_1 - p_n$, can be obtained from the Bernoulli equation by expressing the velocities at the two points in terms of diameters and flow rates as given by Eq (5).

The equations for the pressure differential then become:

$$p_1 - p_n = \sum_{i=1}^{i=n} P_i + 1.123 \times 10^{-3} G^2 S (D_n^{-4} - D_1^{-4}) - 0.4333\, S\, h \tag{12}$$

and

$$p_1 - p_n = \sum_{i=1}^{i=n} P_i + 5.809 \times 10^{-2} W^2 S^{-1} (D_n^{-4} - D_1^{-4}) - 0.4333\, S\, h \tag{13}$$

In these equations, the second term on the right hand side represents the change in pressure resulting from a change in velocity. For example, an increase in the diameter D_n at B results in a decrease in velocity with consequent increase in pressure p_n. A decrease in D_n would increase the velocity and decrease the pressure.

The last term represents the intensity of pressure resulting from the potential head h. This can be either positive or negative; if A is at a higher elevation than B as shown in Fig. 2, it is negative since h is positive. If A is lower than B, it is positive since h is negative.

Substituting the value of the total pressure loss from Eqs (9) and (10) in Eqs (12) and (13):

$$p_1 - p_n = 1.123 \times 10^{-3} G^2 S\, [\Sigma + (D_n^{-4} - D_1^{-4})] - 0.4333\, S\, h \tag{14}$$

and

$$p_1 - p_n = 5.809 \times 10^{-2} W^2 S^{-1}\, [\Sigma + (D_n^{-4} - D_1^{-4})] - 0.4333\, S\, h \tag{15}$$

Solving the preceding equations for G and W, the rate of flow through the circuit is:

$$G = 29.843 \sqrt{\frac{(p_1 - p_n) + 0.4333\, S\, h}{[\Sigma + (D_n^{-4} - D_1^{-4})]\, S}} \tag{16}$$

and

$$W = 4.149 \sqrt{\frac{[(p_1 - p_n) + 0.4333\, S\, h]\, S}{\Sigma + (D_n^{-4} - D_1^{-4})}} \tag{17}$$

For the conditions of Fig. 1 ($h = 0$; $D_n = D_1$), Eqs

(16) and (17) simplify as follows:

$$G = 29.843\sqrt{\frac{p_1 - p_n}{S\Sigma}} \tag{18}$$

and

$$W = 4.149\sqrt{\frac{(p_1 - p_n)S}{\Sigma}} \tag{19}$$

Circuits with Series and Parallel Flow Paths

The hydraulic resistance diagram in Fig. 3 represents a hydraulic circuit with series and parallel flow paths. The pipe line is horizontal and the passages at points A, B and C are of the same diameter.

If the sum of the series resistances between A and B is Σ and the resistance of the parallel flow paths between B and C is denoted by Z, the total resistance of the circuit is $\Sigma + Z$. (20)

Then, in accordance with Eqs (18) and (19), the rate of flow through the series circuit is:

$$G = 29.843\sqrt{\frac{p_1 - p_n}{S(\Sigma + Z)}} \tag{21}$$

and

$$W = 4.149\sqrt{\frac{(p_1 - p_n)S}{\Sigma + Z}} \tag{22}$$

The expression for resistance Z of the parallel flow paths can be derived as follows:

The rate of flow G in the main circuit between A and B is equal to the sum of the flow rates through the parallel paths. Hence, for n parallel paths,

$$G = G_1 + G_2 + G_3 + \cdots + G_n \tag{23}$$

Expressing G in terms of Z and the pressure differential $p_2 - p_n$ across the parallel paths,

$$G = 29.843\sqrt{\frac{p_2 - p_n}{SZ}} \tag{24}$$

The flow rate through each of the parallel paths is:

$$G_1 = 29.843\sqrt{\frac{p_2 - p_n}{S\Sigma_1}} \tag{25}$$

$$G_2 = 29.843\sqrt{\frac{p_2 - p_n}{S\Sigma_2}} \tag{26}$$

$$G_n = 29.843\sqrt{\frac{p_2 - p_n}{S\Sigma_n}} \tag{27}$$

Substituting the preceding values in Eq (23),

$$29.843\sqrt{\frac{p_2 - p_n}{SZ}} = 29.843\sqrt{\frac{p_2 - p_n}{S\Sigma_1}} + 29.843\sqrt{\frac{p_2 - p_n}{S\Sigma_2}} + \cdots + 29.843\sqrt{\frac{p_2 - p_n}{S\Sigma_n}} \tag{28}$$

This resolves into

$$\frac{1}{\sqrt{Z}} = \frac{1}{\sqrt{\Sigma_1}} + \frac{1}{\sqrt{\Sigma_2}} + \cdots + \frac{1}{\sqrt{\Sigma_n}} \tag{29}$$

Solving for Z, the general equation for n parallel flow path is:

$$Z = \frac{1}{\left[(\Sigma_1)^{-1/2} + (\Sigma_2)^{-1/2} + \cdots + (\Sigma_n)^{-1/2}\right]^2} \tag{30}$$

EXAMPLE 1 Assume that in Fig. 3, the sum of the series hydraulic resistances between points A and B including that of the flow control valve, is $\Sigma = 4.68$, and that the resistances of the parallel flow path are $\Sigma_1 = 8.9$, $\Sigma_2 = 15.4$, and $\Sigma_3 = 28.6$. If the pump discharge pressure at point A is $p_1 = 580$ psi, abs, the pressure at point C is $p_n = 400$ psi, abs and the specific gravity of the fluid is $S = 0.785$, what is the rate of flow through the main circuit between point A and B and through the parallel paths in U.S. gpm?

SOLUTION: In accordance with Eq (21), the rate of flow through the hydraulic circuit is:

$$G = 29.843\sqrt{\frac{580 - 400}{0.785(4.68 + Z)}}$$

The value of the resistance Z of the parallel flow paths can be computed from Eq (30). Hence:

$$Z = \frac{1}{(8.9^{-1/2} + 15.4^{-1/2} + 28.6^{-1/2})^2}$$

$$= \frac{1}{(0.3352 + 0.2548 + 0.1870)^2} = 1.656$$

Thus, the flow through the main circuit between points A and B is:

$$G = 29.843\sqrt{\frac{580 - 400}{0.785(4.680 + 1.656)}}$$

$$= 29.843\sqrt{\frac{180}{0.785 \times 6.336}} = 179.53 \text{ gpm}$$

From Eq (9), the pressure loss between points A and B resulting from the series resistances is:

$$p_1 - p_2 = 1.123 \times 10^{-3} \times 179.53^2 \times 0.785 \times 4.68 = 132.95 \text{ psi}$$

The pressure at point B is:

$$p_2 = 580 - 132.95 = 447.05 \text{ psi, abs}$$

The rate of flow through the parallel flow paths can now be computed with Eqs (25), (26) and (27). Thus:

$$G_1 = 29.843\sqrt{\frac{447.05 - 400}{0.785 \times 8.9}} = 77.45$$

$$G_2 = 29.843\sqrt{\frac{447.05 - 400}{0.785 \times 15.4}} = 58.88$$

$$G_3 = 29.843\sqrt{\frac{447.05 - 400}{0.785 \times 28.6}} = 43.20$$

As a check on the analyses, the sum of the rate of flow through the parallel flow paths should equal the rate of flow in the main circuit between points A and B. Thus:

$$G = 77.45 + 58.88 + 43.20 = 179.53 \text{ U.S. gpm}$$

This is in agreement with the value previously computed.

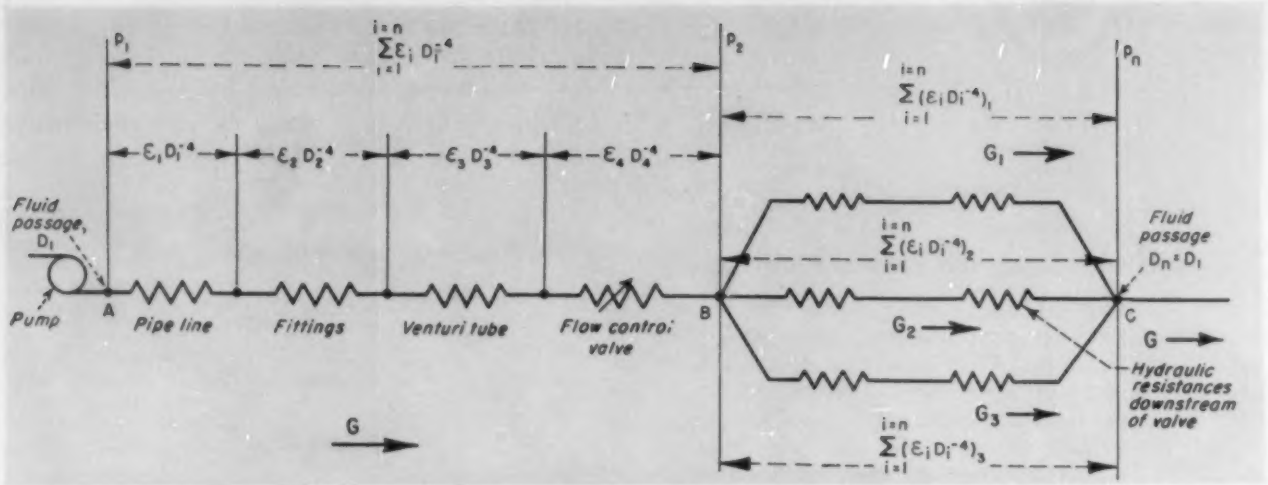


Fig. 3—Resistance diagram with series and parallel flow paths. Expressions for the flow rate in each of the parallel paths are given by Eqs (25)—(28); Eq (30) gives the hydraulic resistance for n parallel paths.

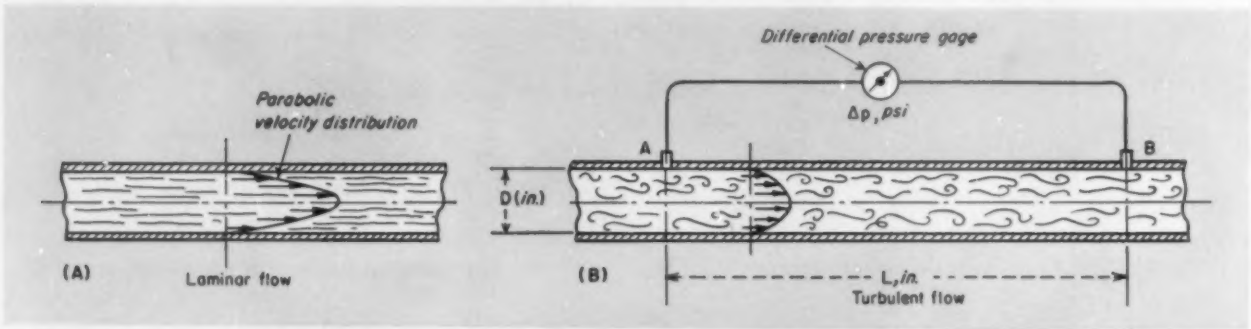


Fig. 4—Velocity distribution for laminar flow (A), and turbulent flow (B). Differential gage in (B) measures the pressure drop.

EQUATIONS FOR THROTTLING ORIFICE OF FLOW CONTROL VALVE

The diameter of the throttling orifice of a flow control valve can be obtained from Eqs (14) and (15) by letting

$$\Sigma = \sum_{i}^{1} \epsilon_i D_i^{-4} + \epsilon_4 D_4^{-4} \tag{31}$$

Substituting the value of the resistance given by Eq (31),

$$D^4 = \sqrt[4]{\frac{\epsilon_4}{\dfrac{890.608[(p_1 - p_n) + 0.4333\,S\,h]}{G^2 S} - \sum_{i}^{1} \epsilon_i D_i^{-4} - (D_n^{-4} - D_1^{-4})}} \tag{32}$$

or

$$D^4 = \sqrt[4]{\frac{\epsilon_4}{\dfrac{17.214[(p_1 - p_n) + 0.4333\,S\,h]\,S}{W^2} - \sum_{i}^{1} \epsilon_i D_i^{-4} - (D_n^{-4} - D_1^{-4})}} \tag{33}$$

The resistance term for the hydraulic circuit, in Eqs (32) and (33) then becomes:

$$\sum_{i}^{1} \epsilon_i D_i^{-4} = \epsilon_1 D_1^{-4} + \epsilon_2 D_2^{-4} + \epsilon_3 D_3^{-4} + \cdots + \epsilon_n D_n^{-4} \tag{34}$$

where the resistance for the valve $\epsilon_4 D_4^{-4}$ is omitted.

Note that in Eqs (16), (17), (32) and (33), the potential head h is positive when point A is at a higher elevation than B, and becomes negative when A is lower than B.

For the fundamental circuit, Fig. 1, Eqs (32) and (33) become:

$$D_4 = \sqrt[4]{\frac{\epsilon_4}{\dfrac{890.608(p_1 - p_n)}{G^2 S} - \sum_{i}^{1} \epsilon_i D_i^{-4}}} \tag{35}$$

and

$$D_4 = \sqrt[4]{\frac{\epsilon_4}{\dfrac{17.214(p_1 - p_n)S}{W^2} - \sum_{i}^{1} \epsilon_i D_i^{-4}}} \tag{36}$$

Similarly, the diameter of the throttling orifice of the flow control valve in circuits with series and parallel flow paths, Fig. 3, can be derived:

RELATION BETWEEN ENERGY LOSS AND DISCHARGE

The coefficient of energy loss ϵ_4, and consequently the coefficient of discharge C_{D4} of the flow control valve vary considerably depending upon the geometry of the throttling orifice during opening and closing of the valve and on the configuration of the fluid passages in the valve. The relationship between ϵ_4 and C_{D4} can be derived as follows:

The flow through a valve in terms C_{D4},D_4, Δp and S can be expressed by the general equation for flow through an orifice, or

$$G = 29.843 C_{D4} D_4^2 \sqrt{\Delta p / S} \tag{37}$$

From Eq (18) the flow through a valve in terms of the hydraulic resistance $\epsilon_4 D_4^{-4}$ is:

$$G = 29.843 \sqrt{\frac{\Delta p}{S \epsilon_4 D_4^{-4}}} \tag{37a}$$

In Eqs (37) and (37a) it is assumed that the inlet and outlet ports are of the same diameter, which usually applies. Equating Eqs (36) and (37) and solving for ϵ_4:

$$\epsilon_4 = \frac{1}{C_{D4}^2} \tag{38}$$

or

$$C_{D4} = \frac{1}{\sqrt{\epsilon_4}} \tag{39}$$

As previously stated, the coefficient of energy loss and the coefficient of discharge depend upon the geometry of the throttling orifice developed during valve opening and closing and on the physical configuration of the valve in general. Therefore, these values must be estimated during the design of the valve since exact values are rarely known before the final laboratory test.

The best procedure is to calculate the diameter of the throttling orifice D_4 from equations previously developed by letting $\epsilon_4 = 1$, and hence Eq (39),

$$C_{D4} = 1/\sqrt{1} = 1$$

In practice, the geometry of the throttling orifice varies and often is not circular. Under these conditions, D_4 can be converted into an equivalent flow area. A curve representing orifice area versus valve lift can then be constructed. Later the actual flow area can be determined by choosing realistic values of C_{D4}, bearing in mind that the flow area is inversely proportional to this factor.

EXPERIMENTAL DETERMINATION OF HYDRAULIC RESISTANCE

When fluid flows through a pipe, the character of the flow depends upon such factors, as specific gravity, viscosity, velocity, pipe diameter, etc. As shown in Figs. 4(A) and (B) the flow may be either laminar or turbulent.

The criterion applicable to all fluids for determining the character of the flow is the dimensionless Reynolds number:

$$R = 7{,}741.920 VD/\nu = 3{,}162.556 G/\nu D$$

or

$$R = 22{,}747.606 W/\nu S D = 22{,}747.606 W/\mu D \tag{40}$$

When the flow is increased slowly in a smooth straight pipe through a carefully rounded entrance, laminar flow has been maintained for values of Reynolds number as large as 50,000 depending upon the care taken to prevent initial disturbing effects such ast those caused by fittings or valves. Under normal conditions laminar flow does not prevail for values of Reynolds numbers above 2,400 to 3,000. When the velocity is gradually reduced the flow pattern reverts back to laminar. The lower critical Reynolds number below which turbulent flow cannot persist is 1,500 to 2,000. Most of the flow dealt with in hydraulic engineering, however, is turbulent. In installations having a large number of bends, fittings, and valves, the flow may be turbulent for values of R as low as 1,000.

The differential gage in Fig. 4(B) measures the pressure drop Δp in the length of pipe L between points A and B If a valve or fitting is installed in the pipe line as shown in Fig. 5(A), considerable disturbance of the flow pattern will occur.

This increase in turbulence may be present in a considerable length of straight pipe downstream of the valve or fitting with consequence increase in energy loss. The disturbance usually persists from 40 or more diameters downstream before normal pattern is re-established, depending upon the magnitude of the disturbance.

If, in each instance, the rate of flow is the same, the pressure loss $(\Delta p)_1$ between points A and B in Fig. 5(A) will be greater than the pressure loss Δp in Fig. 4, because of the resistance of the valve or fitting and the dissipation of energy resulting from the increased turbulence in the line. This later excess loss obviously should be charged to the valve or fitting.

If the length of straight pipe between A and B is $L = L_1 + L_2$, then the pressure loss caused by the valve or fitting is $p_{loss} = (\Delta p)_1 - \Delta p$.

In accordance with Eqs (18) and (19):

$$G = 29.843 \sqrt{\frac{(\Delta p)_1 - \Delta p}{S \epsilon_o D_o^{-4}}} \tag{41}$$

and

$$W = 4.149 \sqrt{\frac{[(\Delta p)_1 - \Delta p] S}{\epsilon_o D_o^{-4}}}$$

Solving for $\epsilon_o D_o^{-4}$, the resistance of the valve or the fitting is

$$\epsilon_o D_o^{-4} = 890.608 \frac{(\Delta p)_1 - \Delta p}{G^2 S} = \Psi \tag{42}$$

and

$$\epsilon_o D_o^{-4} = 17.214 \frac{[(\Delta p)_1 - \Delta p] S}{W^2} = \Psi \tag{43}$$

From the preceding equations the value of the coefficient of energy loss ϵ_o is readily obtained:

$$\epsilon_o = \Psi D_o^4 \tag{44}$$

In Fig. 5 the pipe diameter on the upstream and the

downstream side of the device to be tested is the same. In Fig. 5(B), the pipes are of different size, so that the velocity heads at A and B are of different magnitude. The expression for the flow through the device can be obtained from Eqs (16) and (17) by letting the potential head h equal zero.

Hence:

$$G = 29.843\sqrt{\frac{(\Delta p)_1 - \Delta p}{[\epsilon_o D_o^{-4} + (D_2^{-4} - D_1^{-4})]S}}$$

and

$$W = 4.149\sqrt{\frac{[(\Delta p)_1 - \Delta p]S}{\epsilon_o D_o^{-4} + (D_2^{-4} - D_1^{-4})}}$$

where $(\Delta p)_1$ is the pressure differential between A and B in Fig. 5(B); Δp is the pressure loss in the pipes of length L_1, L_2 and diameter D_1, D_2, respectively, under normal (undisturbed) flow and at the same flow rate.

Solving for $\epsilon_o D_o^{-4}$, the resistance of the device is

$$\epsilon_o D_o^{-4} = 890.608\,\frac{(\Delta p)_1 - \Delta p}{G^2 S} - (D_2^{-4} - D_1^{-4}) = \Psi \quad (42a)$$

and

$$\epsilon_o D_o^{-4} = 17.214\left[\frac{(\Delta p)_1 - \Delta p}{W^2}\right]S - (D_2^{-4} - D_1^{-4}) = \Psi \quad (43a)$$

In the case of a flow control valve, its resistance is comparatively high and the term Δp usually is negligible in practical analyses. For a fitting or check valve with a relatively low hydraulic resistance, however, the value of Δp becomes significant.

A study of laboratory test data indicates that for fittings, such as tees, elbows, unions, etc., and valves for a given throttling orifice area, the quantity ϵD^{-4}, and consequently the coefficients ϵ and C_D remain essentially constant with varying Reynolds number when the flow is well in the turbulent region.

This, however, does not apply to the pipe line where ϵ is a function of the coefficient of friction (and consequently also of the Reynolds number R), and the ratio of the pipe length to the pipe diameter, or

$$\epsilon = fL/D \quad (45)$$

When the flow is laminar, the coefficient of friction f is independent of the roughness of the pipe wall and has the value

$$f = 64/R \quad (46)$$

However, experiments show that when the flow is turbulent, the value of f varies considerably with the degree of wall roughness.

Because of the complexity of turbulent flow along with the difficulty in establishing a numerical scale of roughness, a satisfactory theoretical equation for computing the friction coefficient so far has not been developed. However, by analyzing experimental data, Blasius found that for smooth pipes the friction coefficient f can be expressed by:

$$f = 0.316/\sqrt[4]{R} \quad (47)$$

Eq (47), which is valid for Reynolds numbers up to about 100,000 is represented graphically in Fig. 6, as is Eq (46).

When the Reynolds number exceeds 100,000 the relationship f and R for flow in smooth pipes is given by

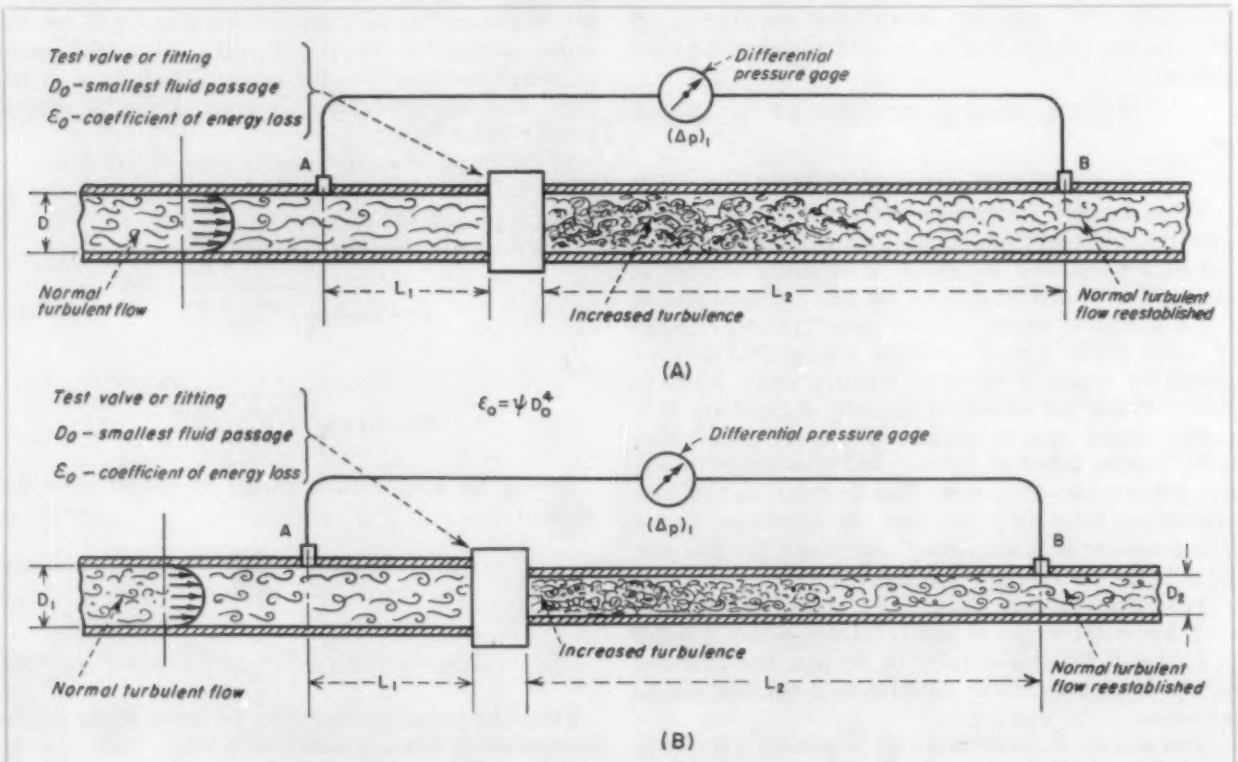


Fig. 5—Test set-ups for checking the flow characteristics of valves or fittings and typical flow patterns that will result. In (A) pipe diameter is constant; in (B) diameters at inlet and outlet valve or fitting are different.

the Karman-Prandtl friction equation:

$$1/\sqrt{f} = -0.8 + 2\log_{10}(R\sqrt{f}) \quad (48)$$

It is not practicable to solve this equation directly for f. The best procedure is to solve for R for various values of f and plot a curve of R versus f as shown in Fig. 7.

In measuring the pressure loss and the rate of flow through hydraulic devices, a test fluid is frequently used with different physical properties than that of the actual service fluid. It will then be necessary to modify the values thus obtained to correspond with actual operating conditions as follows:

If the rate of flow is G (gpm), the pressure loss, specific gravity, and the coefficient of energy loss when using the test fluid and the actual service fluid are P_1, S_1, ϵ_1, and P_2, S_2, ϵ_2, respectively, in accordance with Eq (6):

$$P_2 = P_1 \frac{S_2\epsilon_2}{S_1\epsilon_1} \quad (49)$$

If the flow is measured in W (lb per sec), then from Eq (7):

$$P_2 = P_1 \frac{S_1\epsilon_2}{S_2\epsilon_1} \quad (50)$$

As previously stated the coefficients of energy loss for fittings, such as tees, elbows, unions, etc., and valves for a given throttlings orifice area, remain essentially constant with varying Reynolds number when the flow is well in the turbulent region, in which case $\epsilon_1 = \epsilon_2$ in Eqs (49) and (50). This however, does not apply to pipe lines where ϵ varies considerably with the Reynolds number.

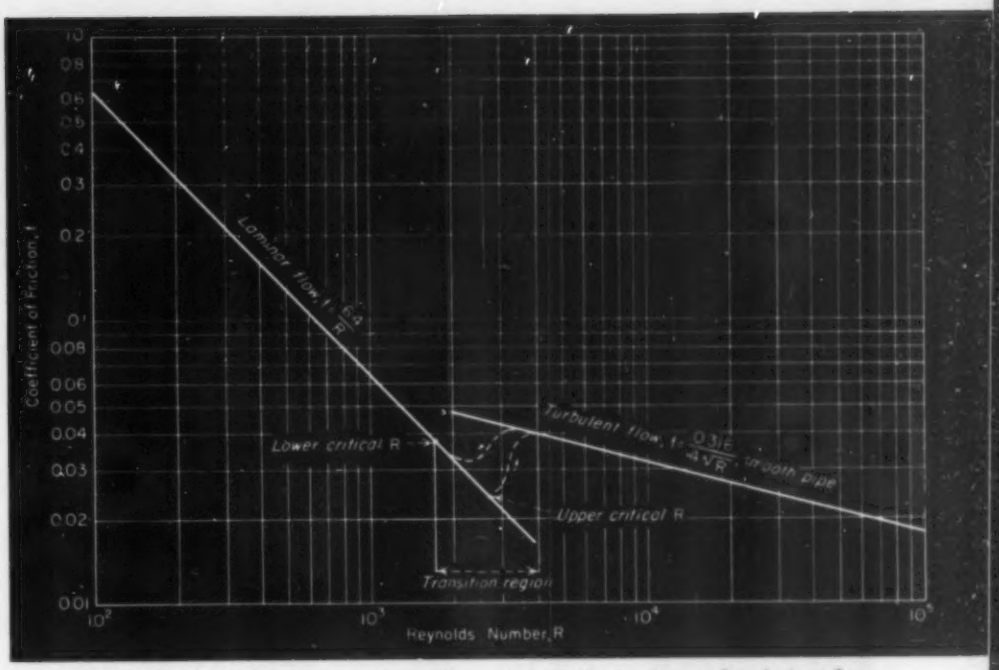


Fig. 6—Coefficient of friction, f, versus Reynolds number, R, for laminar and turbulent flow in smooth pipes.

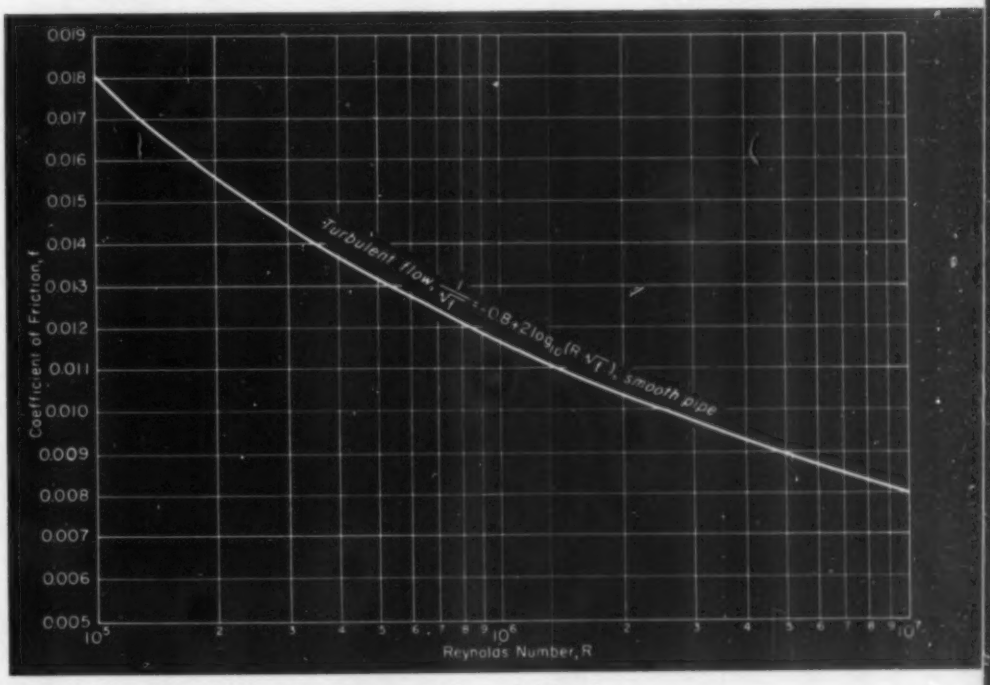


Fig. 7—Enlarged plot of turbulent flow curve shown in Fig. 6.

Since, in accordance with Eq (45) the coefficient of energy loss for a straight pipe is defined as $\epsilon = fL/D$ it follows that Eqs (49) and (50) can be written in the following forms for a straight pipe:

$$P_2 = P_1 \frac{S_2 f_2}{S_1 f_1} \text{ (flow measured in gpm)} \quad (51)$$

and

$$P_2 = P_1 \frac{S_1 f_2}{S_2 f_1} \text{ (flow measured in lb per sec)} \quad (52)$$

After the Reynolds number has been determined, the values of the coefficients of friction f_1 and f_2 can be obtained from charts Figs. 6 and 7.

It is readily seen that the Reynolds number may vary considerably between the laboratory test fluid and the actual service fluid. The test fluid usually is a low viscosity fluid. For example, if the kinematic viscosity of the test fluid is $\nu_1 = 1.1$ centistokes and the Reynolds number is $R_1 = 20{,}000$ then if the service fluid is MIL-O-5606 hydraulic oil at 60 deg F with a kinematic viscosity of $\nu_2 = 25$ centistokes, the Reynolds number when using

the service fluid becomes for the same flow rate

$$R_2 = R_1 \frac{\nu_1}{\nu_2} = 20{,}000 \times \frac{1.1}{25} = 880 \text{ (for flow in gpm)} \quad (53)$$

$$R_2 = R_1 \frac{\nu_1 S_1}{\nu_2 S_2} = R_1 \frac{\mu_1}{\mu_2} \text{ (for flow in lb per sec)} \quad (53a)$$

In this case, the flow is turbulent using the test fluid but becomes laminar under actual operating conditions when the service fluid is used. The value of the coefficients of friction in Eqs (51) and (52) therefore would vary considerably, from $f_1 = 0.0266$ when using the test fluid to $f_2 = 0.072$ when using the service fluid.

It is also seen from Eq (6) that if the pressure loss P is constant and the flow rate is the variable quantity, the following relationship exists:

$$\frac{P}{P} = \frac{1.123 \times 10^{-3} G_2^2 S_2 \epsilon_2 D^{-4}}{1.123 \times 10^{-3} G_1^2 S_1 \epsilon_1 D^{-4}}$$

From this,

$$G_2 = G_1 \sqrt{\frac{S_1 \epsilon_1}{S_2 \epsilon_2}} \quad (54)$$

and similarly from Eq (7),

$$W_2 = W_1 \sqrt{\frac{S_2 \epsilon_1}{S_1 \epsilon_2}} \quad (55)$$

where G_1, W_1 and G_2, W_2 refer to the flow rates using the laboratory test fluid and the actual service fluid, respectively.

For flow through a straight pipe, the preceding expressions assume the following form:

$$G_2 = G_1 \sqrt{\frac{S_1 f_1}{S_2 f_2}} \quad (54a)$$

and

$$W_2 = W_1 \sqrt{\frac{S_2 f_1}{S_1 f_2}} \quad (55a)$$

EXAMPLE 2 Assume that fuel with a specific gravity $S = 0.785$ and kinematic viscosity $\nu = 1.06$ centistokes flows through the circuit represented by the resistance diagram in Fig. 8. The discharge pressure, p_1 of the centrifugal pump at A is represented graphically in Fig. 9. Also assume that the fuel flows through a fuel injector at B. The coefficient of energy loss of the injector assembly is $\epsilon_5 = 5.3$. The pressure, p_n, immediately downstream of the injector due to combustion is represented graphically in Fig. 10. The centrifugal pump is located 10 ft above the injector. The hydraulic line consists of a 180 in. long, 1.00 in. OD, 0.049 in. thick smooth pipe, three 90 deg elbows and one 45 deg elbow. A venturi meter is installed in the pipe line. The pressure loss through the venturi is 6.1 psi at a flow rate of 4.75 lb per sec. The required flow rate versus valve lift is shown in Fig. 10. It is desired to determine the required area of the throttling orifice of the flow control valve.

SOLUTION: The resistance of the various components of the circuit is calculated as follows:

Valve—The graph, Fig. 10, indicates that the required flow rate with the valve fully open at 0.800 in. lift is 4.75 lb per sec.

Pipe Line—From Eq (40a), the Reynolds number is:

$$R = 22{,}747.606 \times \frac{4.75}{1.06 \times 0.785 \times 0.902} = 143{,}962$$

and from Fig. 7 the coefficient of friction is $f_1 = 0.0167$:

From Eq (45), the coefficient of energy loss is:

$$\epsilon_1 = 0.0167 \times \frac{180}{0.902} = 3.33$$

and the hydraulic resistance of the pipe line is:

$$\epsilon_1 D_1^{-4} = 3.33 \times 0.902^{-4} = 5.04.$$

Venturi Meter—Since the pressure loss through the venturi meter measures 6.1 psi, at 4.75 lb per sec flow, its hydraulic resistance, Eq (43), is:

$$\epsilon_2 D_2^{-4} = 17.214 \times \frac{6.1 \times 0.785}{4.75^2} = 3.65$$

Fittings—The coefficients of energy loss for the 90 and 45 deg elbows (0.844 in. ID) are about 1.3 and 0.43 respectively. The hydraulic resistance for four fittings is therefore:

$$\epsilon_3 D_3^{-4} = (3 \times 1.3 + 0.43)\ 0.844^{-4} = 8.54$$

Fuel Injector—The fuel issues through n parallel bell-mouth injector orifices of diameter D (coefficient of contraction = 1). These parallel orifices then can be converted into one equivalent which has the value:

$$D_n = \sqrt{\sum_{i=1}^{i=n} D_i^2}$$

It is also assumed that the equivalent orifice for this specific injector is $D_n = 0.627$ in., and that the coefficient of energy loss for the injector assembly is $\epsilon_5 = 5.3$. The hydraulic resistance of the injector assembly then is:

$$\epsilon_5 D_5^{-4} = 5.3 \times 0.627^{-4} = 34.29$$

Flow Control Valve—The coefficient of discharge for the type of flow control valve shown in Fig. 12 is about $C_{D4} = 0.82$, and from Eq (38), the coefficient of energy loss is:

$$\epsilon_4 = \frac{1}{0.82^2} = 1.49$$

The coefficient of discharge tends to increase slightly (to about $C_{D4} = 0.90$) as the lift decreases, because of the more favorable entrance condition at the lower lifts.

The required diameter D_4 of the throttling orifice can now be computed from Eqs (32) and (33).

Thus, from Eq (33), the resistance term is:

$$\sum \epsilon_i D_i^{-4} = 5.04 + 3.65 + 8.54 + 34.29 = 51.52$$

In accordance with Fig. 10, the rate of flow at 0.8 in. valve lift is $W = 4.75$ lb per sec, and the pressure immediately downstream of the fuel injector is $p_n = 350$ psi, abs.

From Fig. 9, the pump discharge pressure at this flow rate is $p_1 = 445$ psi, abs. Then, substituting in Eq (32),

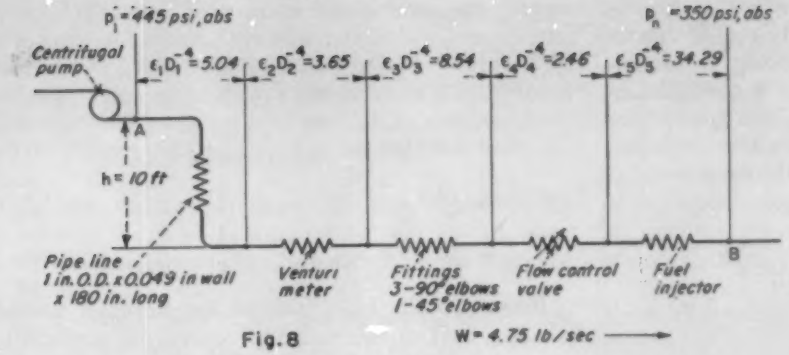
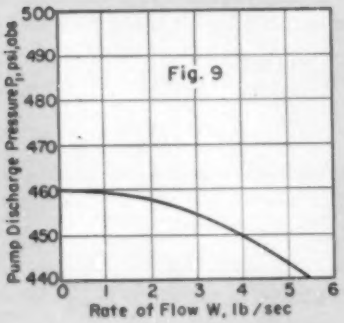
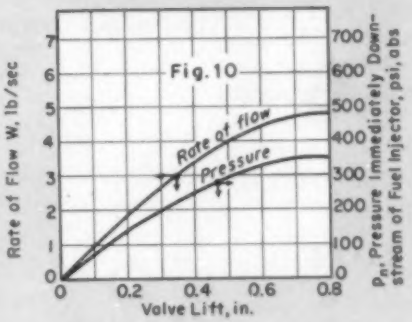


Fig. 8

Fig. 8—Hydraulic resistance diagram for the fuel system of Example 2.





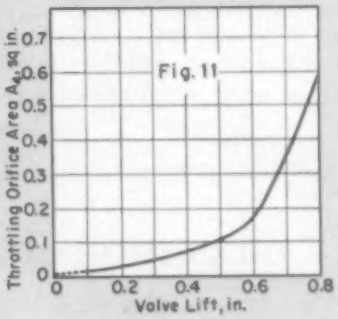
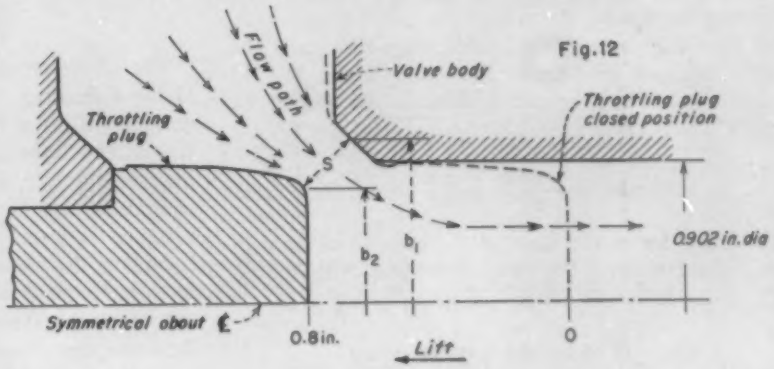


Fig. 9—Pump discharge pressure versus rate of flow.

Fig. 10—Rate of flow, and pressure immediately downstream of fuel injector, versus valve lift.

Fig. 11—Throttling orifice area versus valve lift.

Fig. 12—Flow control valve in which flow rate is determined by an annular throttling device.



the diameter of the throttling orifice is:

$$D_4 = \sqrt[4]{\frac{1.49}{\frac{17.215[(445 - 350) + 0.4333 \times 0.785 \times 10]0.785}{4.75^2} - 51.52 - (0.627^{-4} - 0.902^{-4})}}$$

$$= \sqrt[4]{\frac{1.49}{58.94 - 51.52 - 4.96}} = 0.882 \text{ in.}$$

which converted into an equivalent flow area gives:

$$A_4 = \frac{\pi 0.882^2}{4} = 0.611 \text{ sq. in.}$$

As a check, the rate of flow can now be computed from Eqs (11) and (17).

The coefficient of energy loss of the flow control valve has previously been determined as $\epsilon_4 = 1.49$. The hydraulic resistance of valve is: $\epsilon_4 D_4^{-4} = 1.49 \times 0.882^{-4} = 2.46$

By Eq (11), the hydraulic resistance of the circuit including flow control valve is:

$$\sum_{i=1}^{i=n} \epsilon_i D_i^{-4} = 5.04 + 3.65 + 8.54 + 2.46 + 34.29 = 53.98$$

and substituting in Eq (17):

$$W = 4.149\sqrt{\frac{[(445 - 350) + 0.4333 \times 0.785 \times 10]0.785}{53.98 + (0.627^{-4} - 0.902^{-4})}}$$

$$= 4.149\sqrt{\frac{(95 + 3.40)0.785}{53.98 + 4.96}} = 4.75 \text{ lb per sec}$$

This is the required flow rate with the valve fully open at

0.800 in. lift.

In a similar manner, the required throttling orifice area can be computed for different valve lifts and flow rates. These data are represented graphically in Fig. 11. In the type of valve shown in Fig. 12, the flow is controlled by means of an annular throttling orifice. The rate of flow at any lift is governed by the smallest flow area developed.

The flow area A (sq. in.) is given by the equation:

$$A = 1.5708 \times (d_1 + d_2)\, s$$

where s (in.) is the distance between the boundary surfaces; d_1 and d_2 the respective diameters (in.).

EXAMPLE 3 The pressure loss p_1 through a valve measures 23.5 psi at a flow rate W_1 of 3.5 lb per sec. The test fluid is water at 68 F ($S_1 = 0.998$, $\nu_1 = 1.011$ centistokes). The diameter of the throttling orifice is 0.500 in. What is the pressure loss under actual operating conditions if the service fluid is JP-4 fuel at 120 F ($S_2 = 0.762$, $\nu_2 = 0.715$ centistokes) and the flow rate is the same.

SOLUTION: In accordance with Eq (40a), the Reynolds number using water as test fluid is:

$$R_1 = 22747.606 \times \frac{3.50}{1.011 \times 0.998 \times 0.500} = 157{,}816$$

and using JP-4 fuel

$$R_2 = 22747.606 \times \frac{3.50}{0.715 \times 0.762 \times 0.500} = 292{,}262$$

Because of the high value of the Reynolds numbers, which is well in the turbulent region, the coefficient of energy loss for the valve is essentially the same when water or the actual service fluid is used, so that $\epsilon_1 = \epsilon_2$.

Then from Eq (50), the pressure loss through the valve under actual operating conditions using JP-4 fuel is:

$$P_2 = 23.5 \times \frac{0.998}{0.762} = 30.8 \text{ psi}$$

ESTABLISHMENT OF FLOW

When the velocity of the fluid is increased by opening a valve, pressure energy is dissipated in accelerating the mass of fluid in the pipe line. If the line is long and the valve opens rapidly, the energy dissipated in accelerating the fluid may be of considerable magnitude, and the flow rate will vary with time. For example, let Fig. 13 represent a pipe line in which flow is established by opening a valve. Then, from Newton's second law:

$$\text{Force} = \Delta p \frac{\pi D^2}{4} = m \frac{\Delta V}{\Delta T} \text{ (lb)} \qquad (56)$$

Substituting for m the mass of the column of fluid of length L and expressing the velocity in terms of the rate of flow G (gpm) or W (lb per sec) as given by Eq (5):

$$\Delta P \frac{\pi D^2}{4} = \left(\frac{62.4\pi D^2 LS}{4 \times 12^2 g}\right) \frac{0.4085 D^{-2} \Delta G}{\Delta T}$$

$$= \left(\frac{62.4\pi D^2 LS}{4 \times 12^2 g}\right) \frac{2.938 S^{-1} D^{-2} \Delta W}{\Delta T}$$

The preceding expression resolves into:

$$\Delta p = 4.581 \times 10^{-4} \frac{SL}{D^2} \frac{\Delta G}{\Delta T} = 3.295 \times 10^{-3} \frac{L}{D^2} \frac{\Delta W}{\Delta T} \qquad (57)$$

It is seen from Eq (57), that the pressure ΔP required to accelerate the fluid is directly proportional to the length of the pipe and to the rate of change in flow and is inversely proportional to the square of the inside diameter of the pipe.

Introducing the preceding acceleration terms in Eqs (16) and (17), the rate of flow at any instant during the opening transient of the valve is:

$$G = 29.843 \sqrt{\frac{(P_1 - P_n) + 0.4333 Sh - 4.581 \times 10^{-4} \frac{SL}{D^2} \frac{\Delta G}{\Delta T}}{[\Sigma + (D_n^{-4} - D_1^{-4})]S}} \qquad (58)$$

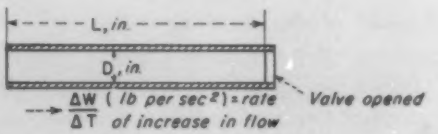
and

$$W = 4.149 \sqrt{\frac{(P_1 - P_n) + 0.4333 Sh - 3.295 \times 10^{-3} \frac{L}{D^2} \frac{\Delta W}{\Delta T}}{\Sigma + (D_n^{-4} - D_1^{-4})}} S \qquad (59)$$

Separation

The phenomenon of separation is responsible for many of the difficulties encountered in the design of hydraulic devices and is a frequent cause of differences between theory and experiment. When the pressure loss in a hydraulic device is unexpectedly high, the presence of separation may be suspected. Separation is, in addition, a source of instability because of the backflow along the boundary, the formation of eddies and consequent increase in turbulence. Separation in a fluid passage depends upon the shape of the solid boundaries, the velocity of the fluid and the pressure gradient.

Figs. 14 and 15 illustrate some typical cases of separation. In Fig. 14(A) the fluid approaches the sharp



ΔT = increment of time in operating valve, sec

ΔV = increase in velocity in time T, ft/sec

Δp = pressure dissipated in accelerating the mass of fluid, psi.

m = mass of fluid the velocity of which is changed, slugs

D = inside diameter of pipe, in.

Fig. 13—Sketch and symbols for illustrating transient flow in pipe after opening of valve. Eqs (58) and (59) give flow rate.

entrance edge of the throttling orifice with high velocity. On the downstream side of the edge, the fluid separates from the boundary and formation of eddies develops. The formation of eddies and increased turbulence result in dissipation of energy. Energy thus dissipated into thermal energy cannot be recovered in useful form and manifests itself as an excessive pressure loss through the hydraulic device.

Separation can be minimized and often eliminated by streamlining the solid boundaries and making all edges around which the fluid is flowing well rounded as shown in Fig. 14(B).

Fig. 15 shows separation in the throat and in the diffuser cone of a venturi tube. In Fig. 15(A), separation is caused by a too large entrance cone angle. In the diverging section, Fig. 15(B), the pressure is increased and the velocity is decreased in the direction of flow. The pressure gradient is therefore positive; often referred to as an adverse gradient.

The layer of fluid near the wall moves with a relatively slow motion. At some downstream point A, the pressure becomes sufficiently high to overcome the momentum of this layer and separation occurs. Because of the adverse pressure gradient backward flow is established and eddies of considerable size may be formed.

Separation in the diffuser cone can usually be eliminated by decreasing the angle of divergence to about 6 to 10 degrees.

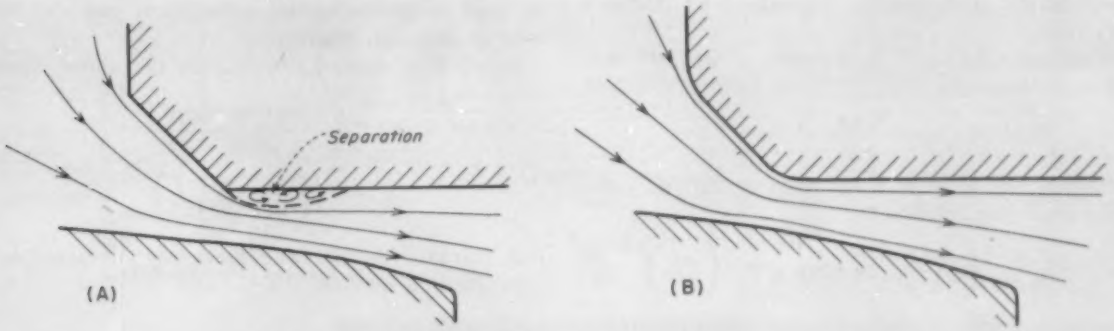


Fig. 14—Separation in throttling orifice is illustrated in (A) when sharp edges are present; (B) shows how rounded boundary eliminates separation.

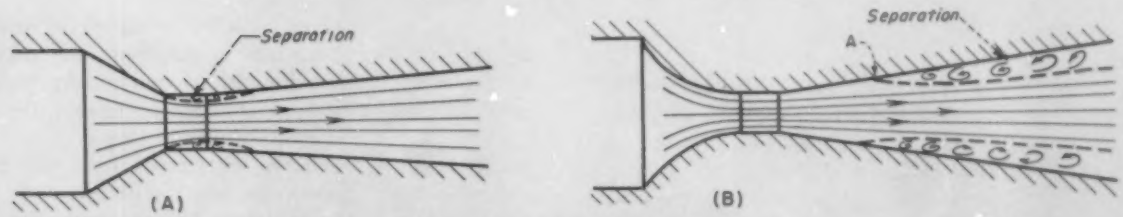


Fig. 15—Flow separation in venturi tubes. In (A) separation (see arrow) in the throat caused by too large entrance cone angle. In (B) separation (see arrow) in the diffuser cone caused by too large angle of divergence.

EXAMPLE 4 The rate of flow G_1 through a smooth straight pipe is 120 U. S. gpm and the pressure loss p_1 is 24.5 psi. The test fluid is water at 68 F ($S_1 = 0.998$, $\nu_1 = 1.011$ centistokes). The ID of the pipe is 0.902 in. What is the rate of flow under actual operating conditions if the pressure loss is the same and the service fluid is MIL-0-5606 hydraulic oil at 80 F ($S_2 = 0.838$, $\nu_2 = 18.5$ centistokes)?

SOLUTION: In accordance with Eq (40), the Reynolds number, using water as test fluid, is:

$$R_1 = 3162.556 \times \frac{120}{1.011 \times 0.902} = 416{,}161$$

and from Fig. 7, the coefficient of friction is $f_1 = 0.0136$.

However, the coefficient of friction f_2 when the service fluid is used is a function of the Reynolds number R_2 which in turn depends upon the rate of flow G_2, which is an unknown quantity. A direct solution to the problem is possible, although somewhat cumbersome. The problem, however, is readily solved by means of approximations:

As a first approximation in determining the coefficient of friction f_2, it can be assumed that the Reynolds number using the service fluid is approximately:

$$R_2' = R_1 \frac{\nu_1}{\nu_2} = 416{,}161 \times \frac{1.011}{18.5} = 22{,}742$$

and in accordance with Fig. 6, $f_2' = 0.0257$.

Then from Eq (54a):

$$G_2' = 120\sqrt{\frac{0.998 \times 0.0136}{0.838 \times 0.0257}} = 95.3 \text{ U.S. gpm}$$

The Reynolds number for this flow rate becomes:

$$R_2'' = 3162.556 \times \frac{95.3}{18.5 \times 0.902} = 18{,}061$$

and from Fig. 6, $f_2 = 0.0273$.

It is therefore concluded that $f_2 > 0.0273 > 0.0257$. As

a final approximation it is assumed that $f_2 = 0.0275$. The rate of flow using the service fluid then becomes:

$$G_2 = 120\sqrt{\frac{0.998 \times 0.0136}{0.838 \times 0.0275}} = 92.1 \text{ U.S. gpm}$$

The Reynolds number for this flow rate is:

$$R_2 = 3162.556 \times \frac{92.1}{18.5 \times 0.902} = 17{,}455$$

and from Fig. 6, $f_2'' = 0.0275$, which is in agreement with the previous assumption.

The following direct solution to the problem is also of interest:

Inspection of Eq (53), which gives the relationship between the Reynolds number and the kinematic viscosity, indicates that the Reynolds number when using the service fluid will be less than 100,000 because of its relatively high viscosity.

In accordance with Eq (47), the value of the coefficient of friction for Reynolds numbers up to about 100,000 is:

$$f_2 = \frac{0.316}{\sqrt[4]{R_2}}$$

Substituting the value of R_2 as given by Eq (40), the preceding expression resolves to:

$$f_2 = \frac{0.316}{\sqrt[4]{3162.556}}\left(\frac{\nu_2 D}{G_2}\right)^{0.25} = 4.214 \times 10^{-2}\left(\frac{\nu_2 D}{G_2}\right)^{0.25}$$

Combining Eq (54a) and the above quotation:

$$G_2 = G_1\left[\frac{S_1 f_1}{4.214 \times 10^{-2}\left(\frac{\nu_2 D}{G_2}\right)^{0.25} S_2}\right]^{0.5}$$

The preceding equation can now be solved for G_2; hence:

$$G_2 = 6.108 G_1^{1.143}\left(\frac{S_1 f_1}{S_2}\right)^{0.571}\left(\frac{1}{\nu_2 D}\right)^{0.143}$$

This equation provides a direct means for computing the rate of flow of the service fluid. It is, however, to be noted that this equation is valid only when the flow of the service fluid is turbulent, and when the Reynolds number is less than 100,000. Eqs. (50a) to (55a), inclusive, are valid for either laminar or turbulent flow and for any value of Reynolds number.

Substituting numerical values in the above equation:

$$G_2 = 6.108 \times 120^{1.143}\left(\frac{0.998 \times 0.0136}{0.838}\right)^{0.571}\left(\frac{1}{18.5 \times 0.902}\right)^{0.143} = 92.1 \text{ U.S. gpm}$$

This checks with the value previously computed by the approximation method.

Cavitation

Cavitation occurs in a hydraulic device wherever the static pressure is reduced to the vapor pressure of the liquid. The liquid then will vaporize and a cavity filled with vapor will form. Cavitation results in vibration, inefficiency, and/or loss in performance. In addition, cavitation is extremely damaging to the material of the hydraulic device. As the cavities are carried by the fluid into regions of higher pressure, the cavities abruptly collapse and the vapor changes back into the liquid phase. This abrupt collapse of the cavities is accompanied by sudden shock forces of exceedingly high magnitude, causing erosion or pitting of the metal surfaces and eventual failure by fatigue.

If the downstream pressure of a venturi tube is gradually reduced while the inlet pressure is maintained constant, the rate of flow and consequently the velocity of the fluid will increase. According to Bernoulli, the pressure in a system decreases with increasing velocity. Therefore, as the velocity at the throat increases, the throat pressure will decrease until it equals the vapor pressure of the liquid. The liquid then will vaporize and cavitation occurs. After cavitation has been established, the rate of flow through the venturi will remain constant regardless of further decrease in the downstream pressure.

This characteristic of the venturi tube is used in the design of hydraulic control circuits to limit the flow to a certain maximum value if the downstream pressure suddenly should diminish; for example, a result of combustion failure in a rocket circuit.

Fig. 16 shows a cavitating venturi and the pressure distribution along the flow path. The curves of pressure gradient represent conditions of constant inlet pressure, constant flow rate and diminishing downstream pressure. As the downstream pressure is gradually reduced, the zone of cavitation will lengthen until the vapor pocket surrounding the high velocity jet extends from the throat for some distance downstream into the diffuser cone. The intensity of cavitation therefore depends upon the magnitude of the downstream pressure. The end of the visible vapor pocket marks the point where cavitation is suppressed. At this point the pressure abruptly begins to rise; for example, as shown at point A.

The pressure loss, $p_1 - p_2$, through the venturi in Fig. 16 is approximately 15 per cent of the pressure differential, $p_1 - p_2$, between the inlet and throat, depending upon the surface finish of the boundary surface. A rough finish will increase the pressure loss considerably. The total pressure loss through the diffuser is determined by the friction, which depends upon the finish of the boundary surface and the length of the diffuser cone; and the loss from vortex motion which depends upon the angle of divergence. A certain degree of vortex motion is always present in a diffuser without separation. However, the intensity of the vortex motion and the dissipation of energy increase rapidly with increasing angle of divergence.

The friction loss in the diffuser can be reduced by increasing the cone angle α, thus shortening the cone. However, the increase in cone angle results in additional dissipation of energy, because of increased vortex motion. It is therefore to be expected that the sum of the friction loss and the loss from vortex motion becomes a minimum for a certain angle of divergence. Experiments indicate

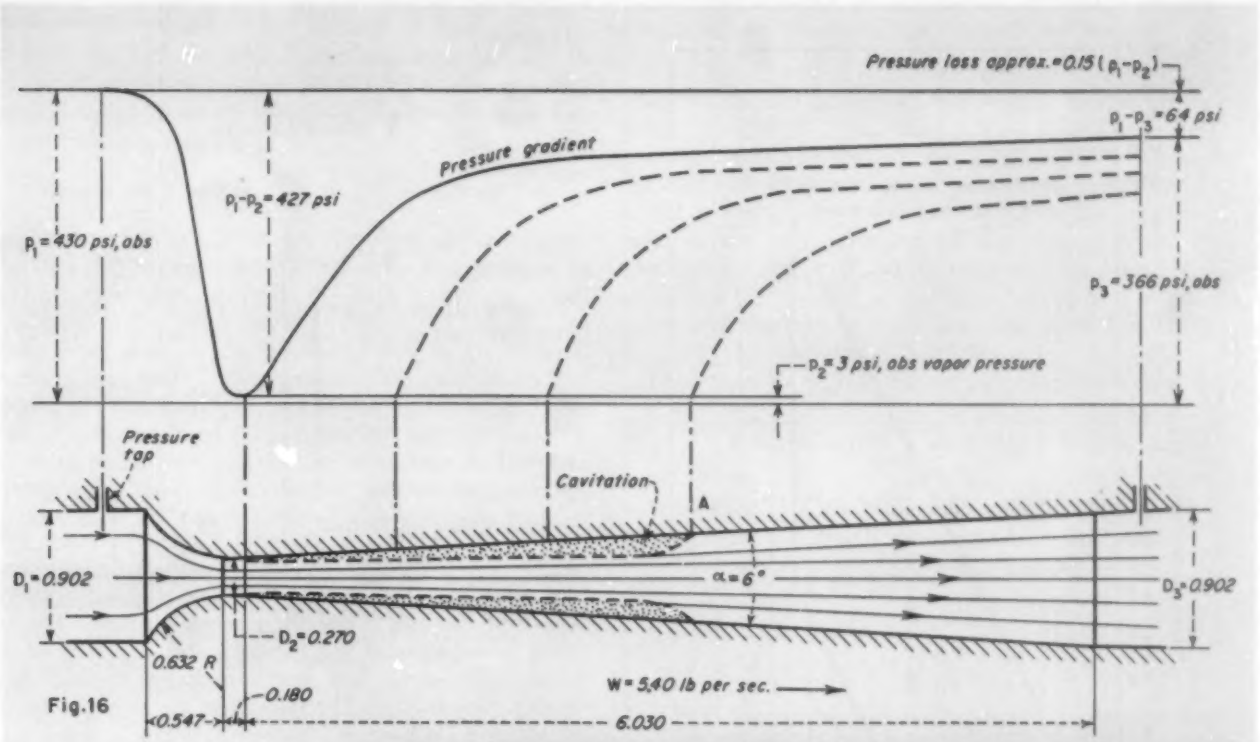
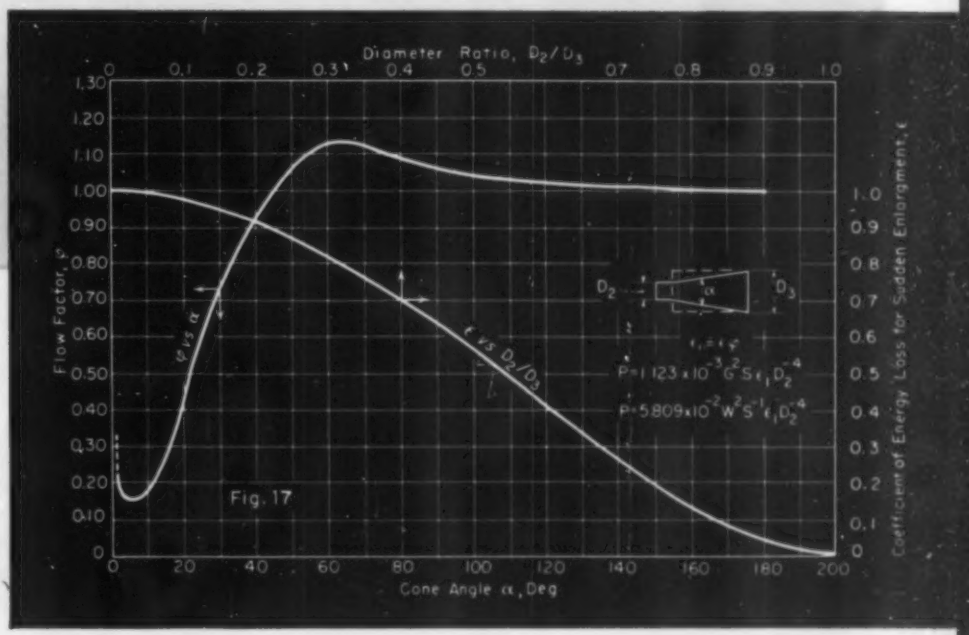


Fig. 16—Cavitating venturi and pressure distribution along the flow path.

Fig. 17—Coefficient of energy loss for diffuser cone.



that in a diffuser with smoothly finished boundary surface the pressure loss becomes a minimum for an angle of divergence α of 6 degrees. If the finish is rougher, the total loss will be greater. The minimum loss then would occur at a slightly larger angle from 7 to 8 degrees.

The coefficient of energy loss ϵ_1 for a smoothly finished diffuser may be determined from Fig. 17. The coefficient ϵ_1 is the product of the coefficient of energy loss ϵ for abrupt expansion and a factor ψ which is a function of the angle of divergence α. For example, if the diameter ratio D_2/D_3 is 0.45 and the angle of divergence α is 15 deg, then the coefficient of energy loss is $\epsilon_1 = \epsilon\psi = 0.63 \times 0.26 = 0.16$. With this coefficient, the pressure loss through the diffuser can be computed by Eqs (6) and (7). The pressure loss between the inlet and throat of a venturi is about 3 to 6 per cent of the velocity head at the throat, depending on shape and finish of the entrance.

Derivation of Design Equations

The rate of flow at which cavitation occurs in a venturi can be derived from Eqs (16) and (17).

If in Fig. 16, p_1, D_1 and p_2, D_2 denote pressures and diameters at the inlet and throat, and the potential head $h = O$ (i.e., the venturi is horizontal), then in accordance with Eq (16), the rate of flow through the venturi is:

$$G = 29.843\sqrt{\frac{p_1 - p_2}{[\epsilon D_2^{-4} + (D_2^{-4} - D_1^{-4})]S}} \qquad (60)$$

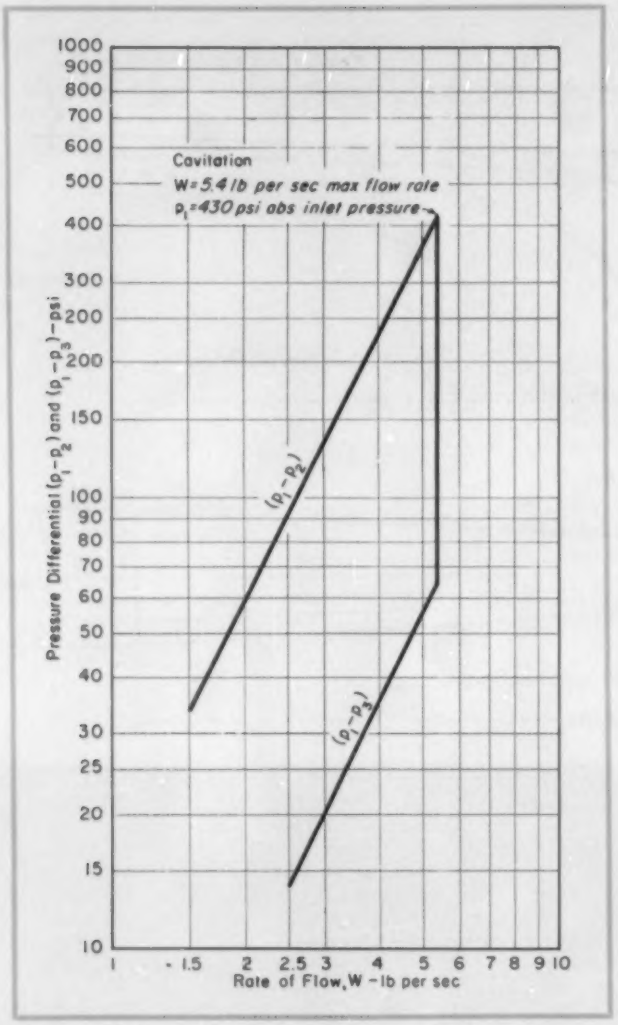


Fig. 18—Hydraulic characteristics of venturi shown in Fig. 16.

In this equation, the resistance term sD_2^{-4} considers the energy dissipated between the inlet and throat. However, in venturi analyses it is convenient to eliminate this term by introducing a coefficient of discharge C_D which then corrects for the dissipation of energy. Eq (60) then takes the form:

$$G = 29.843 C_D \sqrt{\frac{p_1 - p_2}{(D_2^{-4} - D_1^{-4})S}}$$

which can be written

$$G = 29.843 C_D D_1^2 \sqrt{\frac{p_1 - p_2}{\left[\left(\frac{D_1}{D_2}\right)^4 - 1\right]S}} \qquad (60a)$$

From Eq (17):

$$W = 4.149 C_D D_1^2 \sqrt{\frac{(p_1 - p_2)S}{(D_1/D_2)^4 - 1}} \qquad (60b)$$

The rate of flow G or W at which cavitation occurs can now be computed from Eqs (60a) or (60b) by letting p_2 equal the vapor pressure of the liquid.

The equations for the throat diameter of the venturi can be obtained by solving Eqs (60a) and (60b) for D_2; hence:

$$D_2 = D_1 \sqrt[4]{\frac{G^2 S}{890.608 C_D^2 D_1^4 (p_1 - p_2) + G^2 S}} \qquad (62)$$

and

$$D_2 = D_1 \sqrt[4]{\frac{W^2}{17.214 C_D^2 D_1^4 (p_1 - p_2) S + W^2}} \qquad (62a)$$

The equations for the pressure differential between the inlet and the throat become:

$$p_1 - p_2 = 1.123 \times 10^{-3} \frac{G^2 S}{D_1^4} \left[\left(\frac{D_1}{D_2}\right)^4 - 1\right] \frac{1}{C_D^2} \qquad (63)$$

and

$$p_1 - p_2 = 5.809 \times 10^{-2} \frac{W^2}{D_1^4 S} \left[\left(\frac{D_1}{D_2}\right)^4 - 1\right] \frac{1}{C_D^2} \qquad (63a)$$

In Fig. 16 is shown the physical configuration of the venturi of Example 6 and the pressure gradient. The entrance is well rounded to prevent possible separation in the throat under normal flow conditions due to the high fluid velocity. For example, the velocity in the throat is 244 ft per sec at 4.75 lb per sec normal flow and increases to a maximum of 277 ft per sec at a flow rate of 5.40 lb per sec when cavitation occurs. To reduce the pressure loss through the venturi to a minimum, the angle of divergence α of the diffuser cone should be 6 deg as indicated by Fig. 17, and the boundary surface should be smoothly finished. Because of the small cone angle, separation will not occur in the diffuser under normal operating conditions. A diffuser cone angle in excess of 9 to 10 deg is not advisable for this type of venturi as separation may develop because of an adverse pressure gradient. The graph, Fig. 18, represents the pressure differential, $p_1 - p_2$, between the inlet and the throat and the pressure loss $p_1 - p_3$, versus rate of flow. The pressure loss through the venturi is about 15 per cent of the pressure differential between inlet and throat. A pressure loss of 50 psi must therefore be tolerated under the normal flow condition of 4.75 lb per sec.

When the venturi tube is used as a flow rate meter and not as a flow limiting device, the pressure loss can be reduced by increasing the throat diameter, thus reducing the fluid velocity in the throat. The pressure differential between the inlet and throat as well as the pressure loss through the venturi then will be greatly reduced. The pressure loss through the venturi meter in Example 1, for example, is only 6.1 psi at 4.75 lb per sec rate of flow as compared to 50 psi pressure loss through the flow limiting venturi in this example.

Venturi meters often are designed with a conically shaped entrance which blends smoothly into the throat. The included angle of the entrance cone is about 20 degrees. The coefficient of discharge of the venturi meter is a function of the Reynolds number at the throat and the ratio of the throat to inlet diameter. Results of flow tests conducted with cast iron venturi tubes have been published by ASME. Fig. 19 is based on such data and

(continued on page 176)

EXAMPLE 5 If in Fig. 10, of Example 2, the increase in flow rate ΔW of 4.40 − 3.95 = 0.45 lb per sec from 0.5 in. to 0.6 in. lift occurs over a time ΔT of 0.05 sec, the pressure required to accelerate the column of fluid in the pipe line is in accordance with Eq (57):

$$\Delta p = 3.295 \times 10^{-3} \times \frac{180}{0.902^2} \times \frac{0.45}{0.05} = 6.57 \text{ psi}$$

The flow rate at 0.6 in. lift therefore will be slightly less than the required 4.40 lb per sec. The pressure of 6.57 psi required to accelerate the fluid, however, is small compared to the total available differential pressure, or about 4 per cent. Since the rate of flow is proportional to the square root of the pressure differential across the circuit, this discrepancy becomes of negligible value. However, it is readily seen from Eqs (58) and (59) that if the valve opens rapidly, (the rate of change in flow rate is large), the required acceleration pressure becomes significant. This will also be the case with long pipe lines.

EXAMPLE 6 Assume that in the hydraulic circuit, Fig. 8, the downstream pressure abruptly diminishes due to combustion failure, thus causing a sudden increase in flow. It is desired to limit the flow to a maximum value of 5.40 lb per sec by installing a cavitating venturi in the circuit. The pressure loss between the pump and the venturi is 10 psi and the vapor pressure of the liquid is 3 psi, abs. Determine the physical dimensions of the venturi.

SOLUTION: In accordance with Fig. 9, the pump discharge pressure at a flow rate of 5.40 lb per sec is 440 psi, abs. Since the pressure loss between the pump and the venturi is 10 psi, the inlet pressure p_1 to the venturi is 430 psi, abs. The inlet diameter D_1 of the venturi is equal to the inside diameter of the pipe, or 0.902 in. The throat diameter D_2 can be computed from Eq (62a) by letting the pressure at the throat p_2 equal the vapor pressure of the fuel, or 3 psi, abs. The coefficient of discharge C_D for the venturi is 0.970.

Then from Eq (62a), the required throat diameter is:

$$D_2 = 0.902 \sqrt[4]{\frac{5.40^2}{17.214 \times 0.970^2 \times 0.902^4 (430 - 3)\, 0.785 + 5.40^2}}$$

$$= 0.270 \text{ in.}$$

As a check, the maximum rate of flow (at which cavitation occurs) can now be computed from Eq (60b):

$$W = 4.149 \times 0.970 \times 0.902^2 \sqrt{\frac{(430 - 3)\, 0.785}{\left(\frac{0.902^4}{0.270}\right)^4 - 1}}$$

$$= 4.149 \times 0.970 \times 0.902^2 \sqrt{\frac{427 \times 0.785}{124.558 - 1}} = 5.40 \text{ lb per sec}$$

This is in agreement with the maximum permissible flow stipulated above.

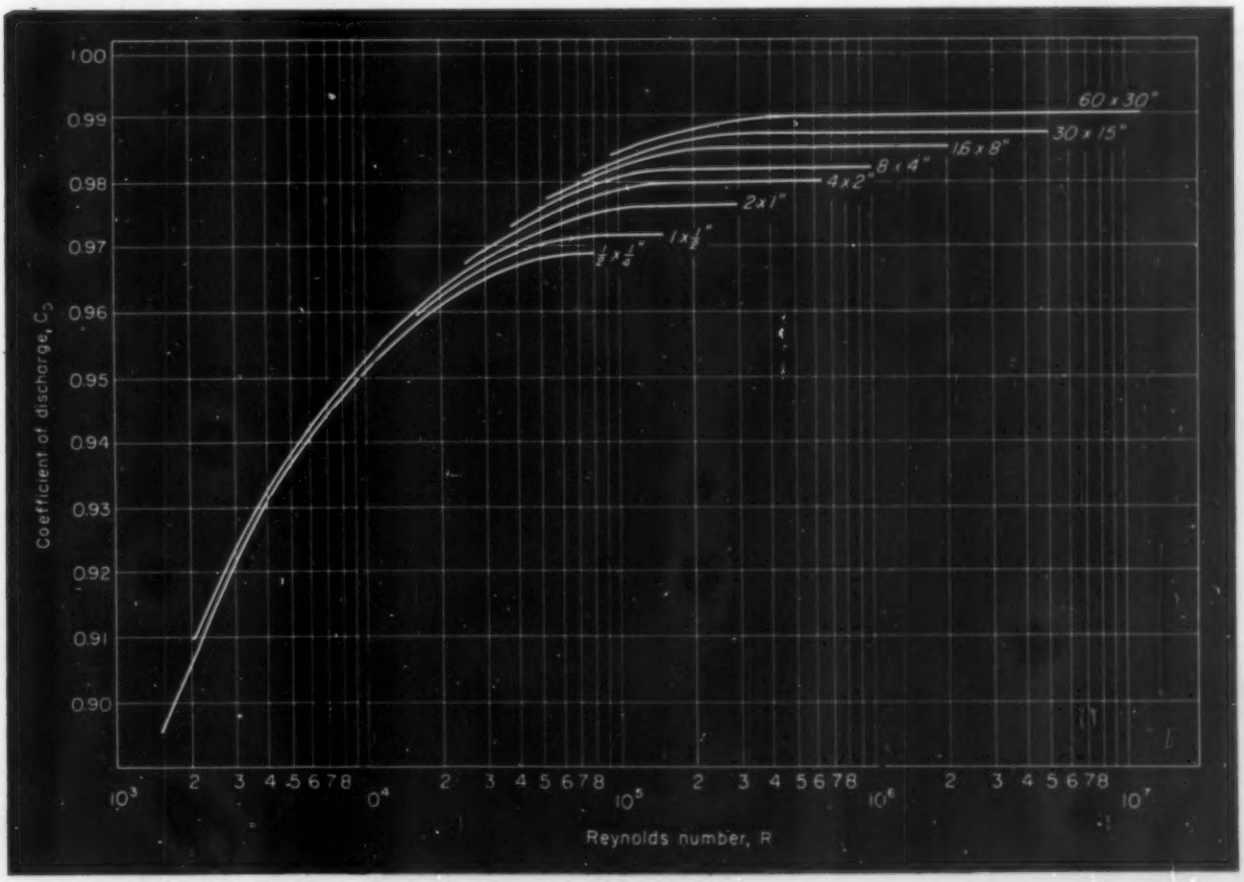


Fig. 19—Coefficients of discharge versus Reynolds number for venturi tubes with throat to inlet diameter ratios of 0.50.

gives the coefficient of discharge C_D, versus Reynolds number, R, at the throat for venturi tubes with a throat to inlet diameter ratio of 0.5. The coefficient of discharge C_β, for other diameter ratios may be computed from Professor Pardoe's equation:

$$C_\beta = \left[\frac{1 - \beta^4}{(1 - \beta^4) + \left(\frac{0.9375}{C_D^2} - 0.9375 \right)} \right]^{1/2} \qquad (64)$$

where β is the ratio of the throat to the inlet diameter, and C_D is the coefficient of discharge for a venturi tube of throat to inlet diameter ratio of 0.5 and having the same diameter of throat as obtained from Fig. 19. For example, if from Fig. 19, the coefficient of discharge, C_D, is 0.962 then from chart, Fig. 20, the coefficient of discharge, C_β, is 0.959 for a venturi tube with the same throat diameter, but with a throat to inlet diameter ratio, β, of 0.6.

The coefficient of discharge is also affected by boundary roughness. Since the values of C_D given in Fig. 19 are for venturi tubes with machined throat but with unfinished entrance cone and diffuser, C_D for a venturi tube with smoothly finished boundary surface will be slightly higher because of the smaller frictional resistance between inlet and throat. However, the values given in the chart probably will be accurate within one percent. When the venturi has been in service some time, the boundary surface may become rough and the coefficient of discharge will decrease somewhat.

The character of the flow entering the venturi tube also will affect its hydraulic characteristics. Considerable disturbance may be caused to the flow pattern by hydraulic devices, bends, fittings, etc. on the upstream side of the venturi. It is therefore of importance that the venturi be preceded by a sufficient length of straight pipe to permit normal flow pattern to be re-established before the flow reaches the upstream pressure tap. In some instances 100 or more diameters of straight pipe may be required, depending on the magnitude of the disturbance caused to the flow. A spiral flow, for example, will increase the pressure at the wall due to the centrifugal effect. The measured pressure differential between the inlet and the throat therefore will be too low and calibration of the venturi will show a too high value of C_D, in some instances exceeding unity. Spiral flow may be eliminated by installing straightening vanes upstream of the venturi meter.

When great accuracy is required it is always advisable to calibrate the venturi meter under laboratory conditions identical to, or simulating, the actual installation.

This marks the third significant contribution to the field of fluid flow made by Mr. Sverdrup. The other two which are on related problems appeared in the following back issues of *Product Engineering:*

1. "Calculating the Energy Losses in Hydraulic Systems," April 1951, page 146.

2. "Pressure Surges in Hydraulic Circuits," September 1953, page 161.

The first of these articles presents a graphical method of solving for the frictional and energy loss coefficients of standard fittings, circular pipes and other hydraulic circuit components.

The second article discusses water hammer in hydraulic piping and includes a method of calculating the amplitude of pressure waves that result from rapid and from gradual valve closure of simple and compound pipe lines. It also includes a method of calculating the capacity of air accumulator required to suppress pressure surge and examples of all the analyses.

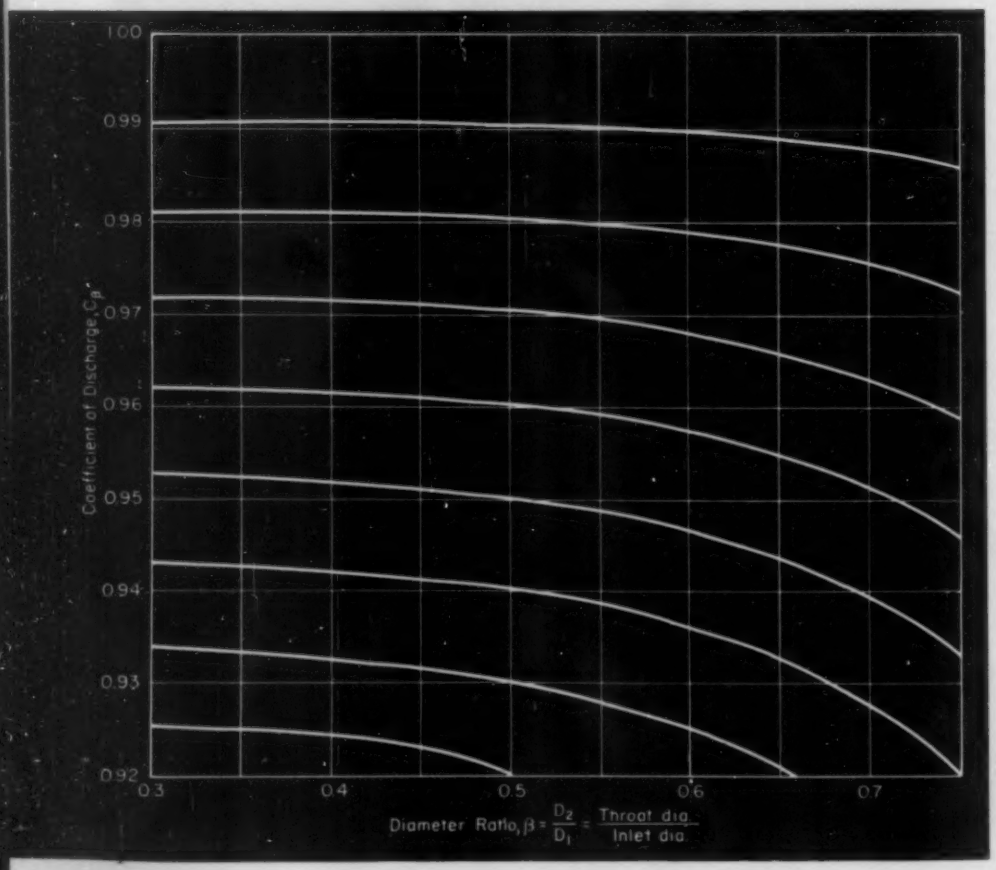


Fig. 20—Variation of venturi tube coefficients with diameter ratio; the throat diameter and Reynolds number being constant.

Predicting Fatigue Failures Of Notched Specimens

ROY A. MILLER

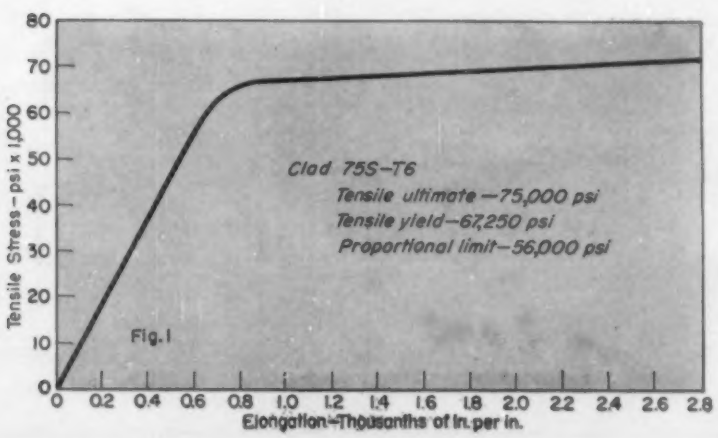
Structural Design Specialist, Consolidated Vultee Aircraft Corporation

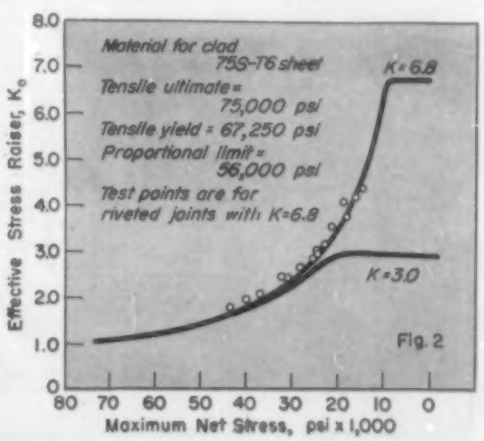
A THOROUGH STUDY of the phenomenon of crack propagation and failure of notched specimens—plus a review of extensive test data—reveals that the so-called stress raiser constant K is actually a strain raiser and that it should be so considered when the peak stresses exceed the proportional limit of the material. Peak stresses less than the proportional limit K can be considered as either a stress or a strain raiser.

With this approach, it is possible to predict the fatigue failure of notched specimens using S-N curves of unnotched specimens: (1) if the cycles to failure at a certain stress level and the stress ratio are comparable for a notched specimen, and (2) the notched specimen peak stress and the unnotched specimen stress are equal, the peak stress being the product of the average stress over the net section and the effective stress raiser constant K_e. Also, conventional thinking in terms of stress can be retained by introducing an appropriate reduction in K with increase in stress level.

Consider the stress-strain curve of Fig. 1 as typical for clad 75S-T6 sheet material. Assume a stress raiser K of 3.0 and a stress level of 30,000 psi, which occurs at a strain of 0.000324 in. per in. The peak stress, being the product of the stress and the stress raiser constant, would be 90,000 psi, a value in excess of the ultimate strength of the material. If however, K is considered as a strain raiser, the product is 0.000972 in. per in, which, from the curve of Fig. 1, occurs at a stress of 67,400 psi. The ratio of 67,400 to 30,000 indicates the effective stress raiser to be 2.247. Assuming a number of stress levels at convenient intervals and determining the values of K_e in the same manner, they may be plotted to form the curve shown on Fig. 2. A second and similar curve is also shown on this plot for a stress raiser constant of 6.8.

In Fig. 2 are also shown points obtained from tests of riveted clad 75S-T6 lap joints in which the stress raiser constant was 6.8 by photoelastic determination. Knowing the stress ratio and the number of cycles at failure, a set of S-N fatigue curves for the sheet material in question, such as are to be found in NACA TN 1485, was used to obtain the maximum peak stress in each case. The ratio of this peak stress to the average maximum net stress used in the test yields the value of the effective stress raiser K_e. It can be seen that the test values agree with the K_e curve obtained from the material stress strain curve for the stress raiser in question. It was therefore concluded that this offers a convenient approach to the problem of predicting the fatigue failure of a notched specimen or part through the following easy steps: First, obtain a stress strain curve for the material in question. Then plot a K_e curve as in Fig. 2 and as outlined above for the stress raiser constant in question. From this curve and at the stress level of interest, select the appropriate value of K_e. Using the product of K_e and the stress level, together with the given stress ratio, the cycles at failure can be read directly from a fatigue S-N chart for the unnotched material.

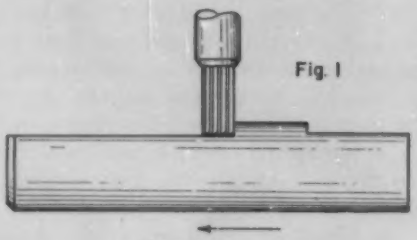



Effective Stress Raiser, K_e
Maximum Net Stress, psi x 1,000
Material for clad 75S-T6 sheet
Tensile ultimate = 75,000 psi
Tensile yield = 67,250 psi
Proportional limit = 56,000 psi
Test points are for riveted joints with K=6.8
K=6.8
K=3.0
Fig. 2

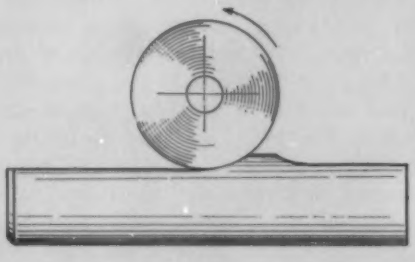
PART III

Designing for Production

Advantages and economies can be derived if components are designed to reduce non-cutting motions of machine members or tools. Simple modifications of the



(A) Original



(B) Redesign

Fig. 1

Fig. 1—Milling flats and keyways on shafts. In (A) small diameter end-mill generates a square step requiring axial and transverse movement of the worktable. Cuts must be light. A large diameter circular cutter as in (B) has a curved runout—equal to radius of cutter—but requires only axial worktable travel. Cutter is slightly wider than required flat. Heavy cuts can be taken and flat milled in a single pass. Machine cutting time savings can range from 10 to 30 per cent.

Fig. 2—Bellcrank lever bossed to simplify holding. Casting has bossed surfaces *a*, *b*, *c*, and *e* that must be accurately faced. Workpiece must be located from *a* to machine other faces. Since *a*, *b*, *c*, are not in line, *b*, and *c* must be braced during cutting. As redesigned in (B), these problems are minimized. Cast-on lugs, *b* and *j*, equalize boss height. Lugs ensure a rigid three point support on machine table or against a chuck face and are removed when holes *f* and *g* are drilled.

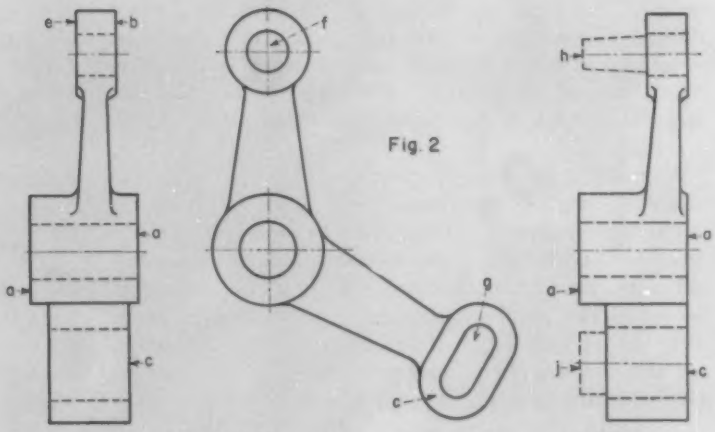


Fig. 2

(A) Original

(B) Redesign

Fig. 3—Split rings replace machined shoulder to reduce material and machining costs. Because diameter of stock in (A) must be greater than *x*, machining of shoulders results in material waste of about 45 per cent. Shoulders locate a roller bearing set, a gear with a locknut, a thrust bearing, and a ball bearing with an end nut. Design in (B) has a material loss of less than 15 per cent of original bar. Eliminating threads and locknuts mean additional savings.

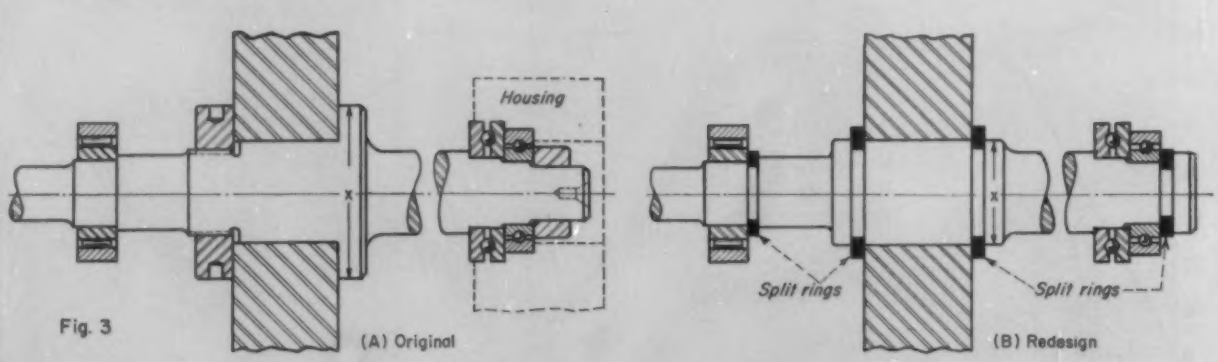


Fig. 3

(A) Original

(B) Redesign

....Reducing Waste

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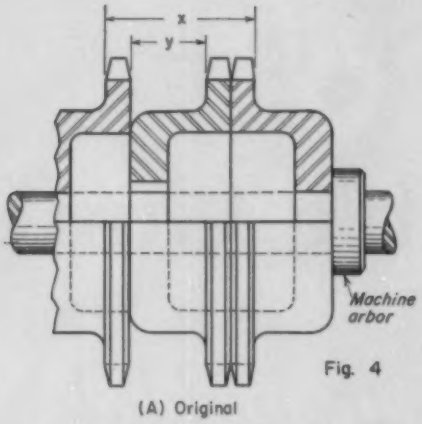
shape of a part can often increase production. Also, scrap loss can be reduced. This, the third of a series, shows various methods of saving machining time and material



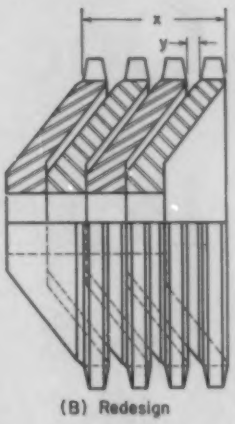


Fig. 4

Fig. 4—Redesign of sprocket and gear blanks for faster machining. Teeth are reproduced either by a circular hobbing tool or a rack-shaped cutter which travels parallel to the axis of the shaft. In (A) only three blanks can be mounted within distance *x* which is the effective machine travel, leaving wide gap *y*. In (B) is a design modification that permits mounting four components within the same distance. Thus *y* is reduced and a 25 per cent saving on cutting time can be realized.

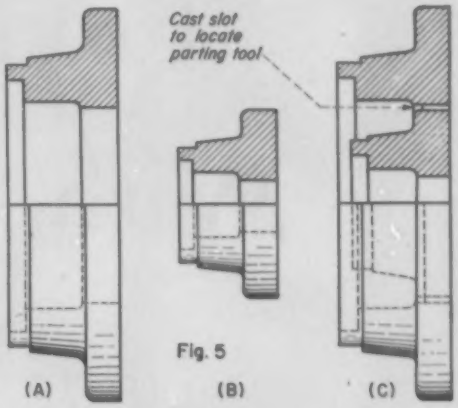


Fig. 5

Fig. 5—Single casting for two components. Two castings of identical shapes but different size are shown in (A) and (B). Originally, two patterns and molds were needed as well as separate setup and machining operations. By combining the units as shown in (C), all surfaces are machinable at two lathe settings and only a single pattern is required. A final machining separates the castings.

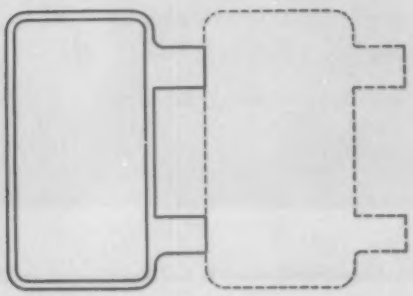


Fig. 6

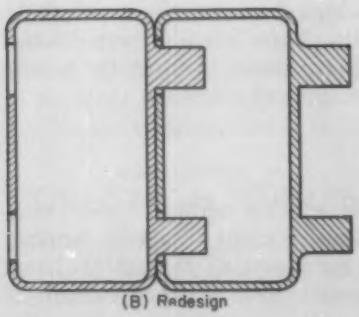


Fig. 6—Box casting has two lug extensions used for attaching hinge. Top surfaces are milled. In (A) lugs increase the table travel by about 15 per cent. A modification, (B), decreases machine time without increasing setup time. Two slots are cast or machined into the wall of the casting to engage lugs.

Fig. 7—Material saving on punching operation. Usually, sheet metal links are designed as shown in (A). Stock is about 25 per cent wider than link to ensure safe and accurate cutting. Altering the design as in (B) reduces waste. Cropping-tool is simpler, less costly and easier to operate than punch; also, length of cut is 2½ times less than that of the blanking punch. Thus, less pressure is required, tool is more durable and closer accuracy is possible.

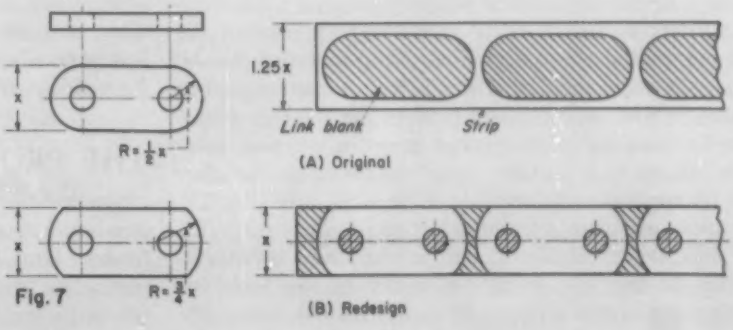


Fig. 7

Spot Welding From One Side— With a Portable Gun

Using the inert-gas shielded tungsten-arc process . . .

Speeds fabrication of large complex assemblies, reduces jigging and fixture costs, can replace or supplement other joining methods, and join sections up to 0.125 in. thick at points generally inaccessible by other welding means. Joint strength comparable to resistance spot welding can be obtained. How seven variables can affect weld quality, with a discussion of standards and test procedures to use in checking results.

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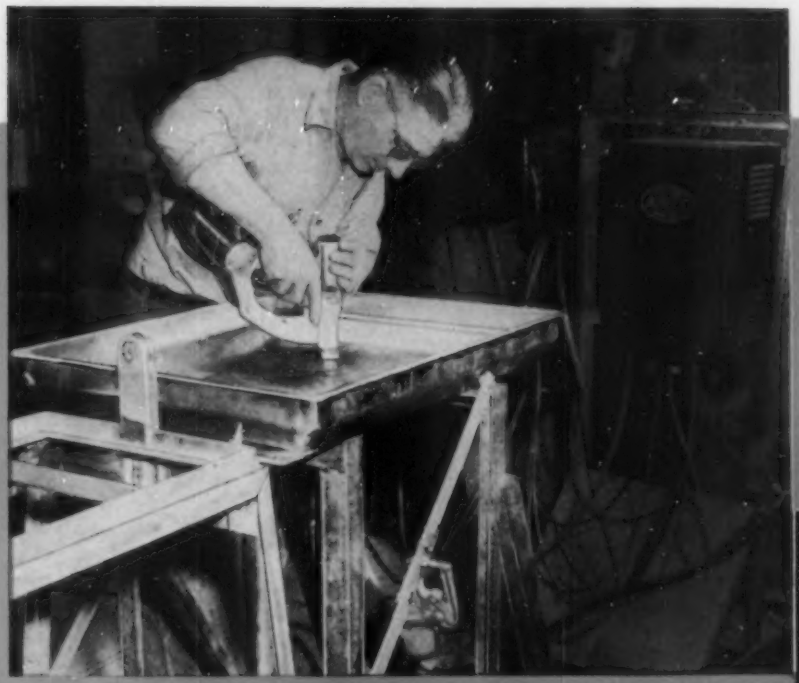
OFTEN A MAJOR LIMITATION of double-electrode resistance spot-welding is lack of ready access to both sides of the work for application of electrodes. Not only must this be borne in mind in the design of a part, but often expensive jigs and fixtures are necessary to hold the work in preparation for welding. Gas shielded tungsten-arc spot welding by means of a portable "gun" which holds the electrode for application to one side of the work only (Fig. 1), thus opens up many interesting design possibilities. With this process the electrical circuit is completed by attaching the positive lead from the weldor to the back (or lower) piece at any convenient point and not necessarily at the point of weld.

Materials suited to welding from one side include mild, alloy, and stainless steels. There has also been limited, but generally successful, experience in using the process for welding copper, titanium and zirconium.

THE PROCESS

For welding from one side, an inert-gas shielded-tungsten arc is used to produce a circular weld by localized fusion. Heat from the arc penetrates through the front piece into the back piece to obtain required depth of fusion in the back piece. Welding of lap joints in this manner is most common; however, square-groove butt



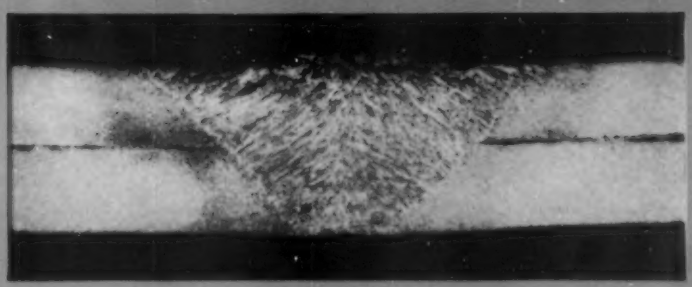


Fig. 1—Rapid spot-welding of a stainless-steel meat tray to stainless bracing underneath, using a single-electrode gun. Thickness of material is 0.062 in. for the meat tray (front piece) and 0.125 in. for the bracing (back piece). The resulting welds are free of indentation or build-up, thus avoiding any subsequent finishing operation. The weld cross-section shown is typical of careful production.

When to Consider Spot Welding From One Side

1. To join two sections, where the front (or top) sheet is not greater than 0.060 in. in thickness.
2. When joints are lap, square-groove butt, T, or corner.
3. When lack of access prevents resistance spot welding.
4. To replace other joining methods, such as plug welding or riveting.
5. To tack weld before final assembly of parts, thus eliminating jigs and fixtures.
6. When number of welds is insufficient to justify expense of large resistance spot-welding equipment.
7. For multiple joints that would require readjustment of large work pieces under the resistance spot-welding machine for successive spots.

joints, T joints and corner joints can also often be welded satisfactorily. A typical weld produced is shown in cross-section in Fig. 1. Available equipment limits thickness of the front piece to about 0.125 in.; but the back piece can be any thickness within certain practical limits.

HOW THE EQUIPMENT OPERATES

The complete equipment necessary to weld from one side is block-diagrammed in Fig. 2. The gun operates on d-c, straight polarity. When the gun is pressed against the front piece at the point of welding, depressing the "trigger" starts the flow of cooling water and shielding gas. Depressing the trigger a second time advances the negative electrode (which is along the axis of the gun barrel) to contact the work. The electrode is automatically retracted to establish the arc which is subsequently extinguished after a preset time. Flow of shielding gas and cooling water is also stopped automatically after the weld is completed.

FACTORS AFFECTING WELD QUALITY

Weld strength depends primarily on spot diameter at the point of joining, and by depth of fusion into the back piece (Fig. 3). Factors which affect diameter and depth

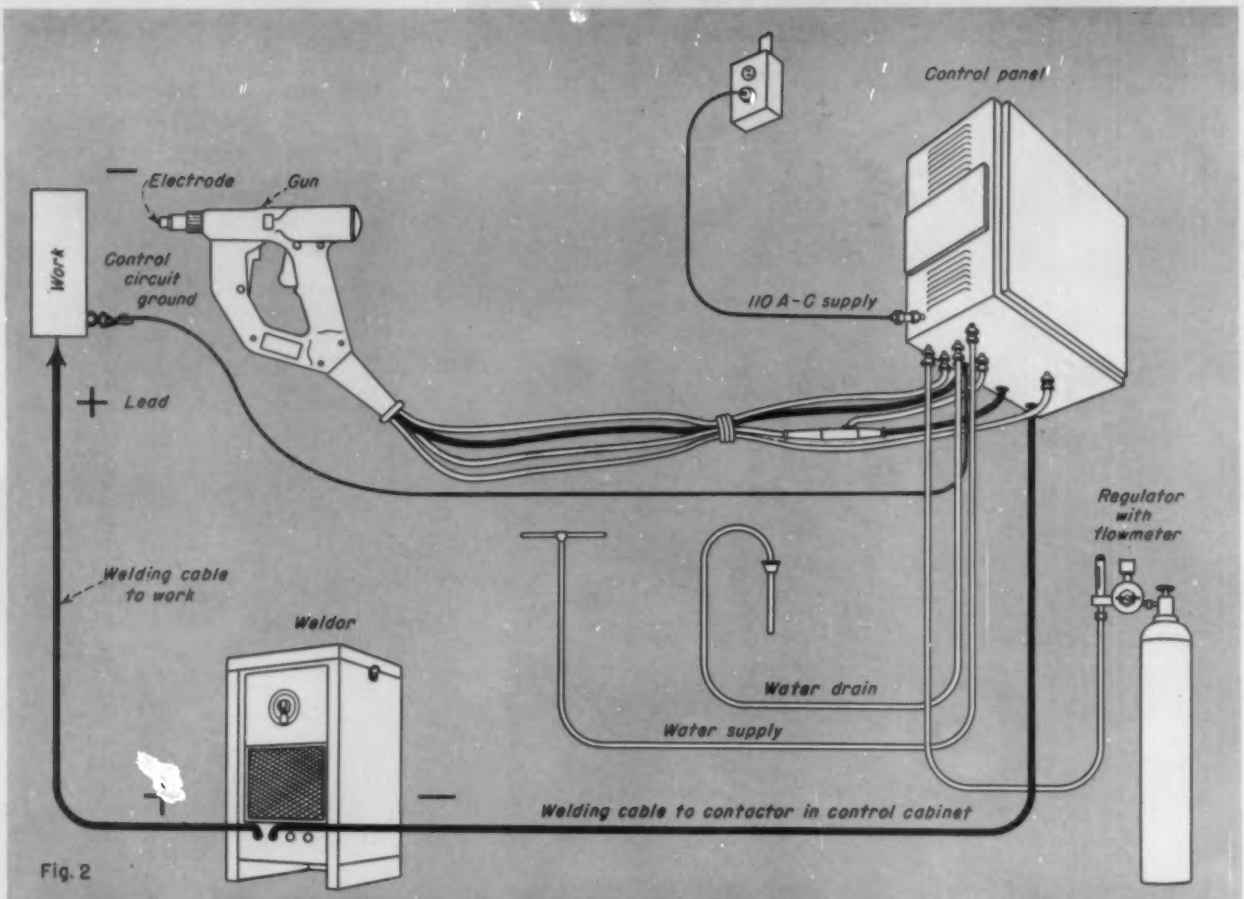


Fig. 2—Equipment and connections for spot-welding from one side. Completion of the electrical circuit is accomplished by attaching the positive lead from the "Weldor" to any convenient point on the work piece. The flow of cooling water and shielding gas is automatically regulated when the gun trigger is pulled.

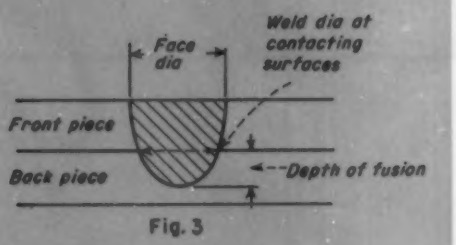


Fig. 3—A one-side spot weld must penetrate completely through the front piece with fusion into the back piece. The weld diameter and depth of fusion must be sufficient to provide required strength.

of fusion are: current, weld time, flow and type of shielding gas, whether a backing plate is used, size and shape of the welding electrode, arc length, material to be joined and its condition, and fit up. Relationship of these factors and their effects on weld characteristics is given in Table I. Sectional views of welds under typical and ideal conditions are shown in Table II. In general, depth of fusion is greater with helium gas than with argon; however, argon generally produces a larger weld diameter than helium. With cold-rolled steel, used in the examples shown, helium gives superior results to argon at lower process cost. The strength of weld in the top illustration is about equal to the third one down yet required only about three-fourths the current for half the time. Besides, the course grain of the weld with argon may be undesirable. A mixture of 65 per cent helium and 35 per cent argon was used in the center illustration and resulted in good grain structure, considerably greater diameter than the helium weld and complete penetration without appreciable increase in weld time or current.

THICKNESS OF MATERIAL—There are general limitations on maximum sheet thickness for successful welding from one side. Because it is necessary to heat through the front piece into the back piece, thickness limitations apply primarily to the front piece. The gun, known as Aircospot,* is designed for use with front sheet thickness to 0.125 in. For front sheet thickness to about 0.060 in., the back sheet can be any practical thickness; for front sheet from about 0.060 in. to 0.094 in., the back sheet must be reduced in thickness toward 0.500 in.; for a front sheet of approximately 0.094 in. to 0.125 in. the back sheet should be 0.250 in. to 0.500 in. maximum, depend-

*Aircospot is a registered trademark of Air Reduction Co., Inc.

Table I—Effect of Variables on Weld Characteristics

Variable	Effect
Current	Increasing current generally increases depth of fusion. When bottom part is heavy or backing is used, weld diameter generally increases.
Weld time	Increase in weld time generally increases weld diameter.
Arc length	Increase in arc length decreases depth of fusion and increases weld diameter. Excessive arc length produces poor results.
Shielding gas	
Helium	Generally greater depth of fusion results with smaller weld diameter than when using argon.
Argon	Generally greater weld diameter with less depth of fusion than with helium.
Helium-Argon mixture	Generally used as two parts helium to one part argon by volume for quality work. Weld pattern is approximately midway between helium & argon patterns.
Shielding gas flow	6 cu ft/hr for most applications is satisfactory if face of nozzle is in complete contact with the work; higher flows are needed if the nozzle is not in good contact. Gas protects both the weld and the electrode.
Backing	
Steel	If parts are thin, fusing to the backing may occur if excess heat is used.
Copper	Good to support thin parts—permits higher heat on medium-thick parts to get larger weld without excess depth of fusion.
Surface Condition	Any factor which tends to minimize heat transfer into the bottom part reduces weld strength and quality. Oil, dirt, grease, scale, paint, etc. should be removed.
Fit-up	Firm contact is required to produce a weld.
Weld diameter	Weld strength increases with weld diameter provided there is sufficient depth of fusion.
Depth of fusion	Must be sufficient to give required strength.
Material	Various materials possess widely different thermal conductivities. Thermal conductivity can affect weldability because of rate of heat transfer from front to back pieces. For instance, thermal conductivity of mild steel is about four times that of the 18-8 variety and about twice that of the straight chrome group. Less current and weld time generally would be required for mild steel to produce a given-strength joint.

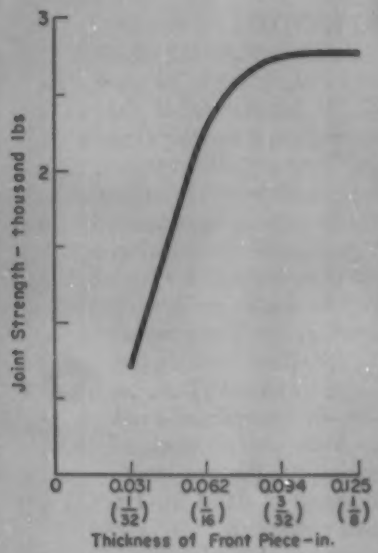


Fig. 4—How strength of joint on mild steel can be increased by adjusting current and weld time as thickness of material is increased. Maximum strength is obtained at approximately 0.094 in. thickness of front piece.

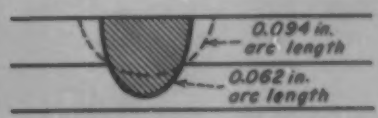
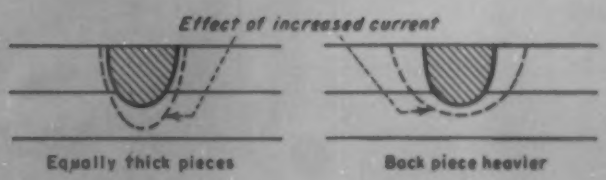


Fig. 5—Effect of arc length on weld. Increasing arc length gives much the same effect as increasing welding time and reducing the current. Depth of fusion is reduced, and with stainless steel radial cracks may result from excessively long arc.

Fig. 6—As the back piece is made heavier, the effect of increasing current is to increase weld dia at a greater rate than depth of fusion, as shown at right. For a thin back piece, increasing current may cause "melting through" of the back piece before the dia is sufficient to develop required strength. Increasing weld time increases dia at greater rate than depth of fusion in the manner of the illustration at right (dotted curve).



ing on the material being joined. Good contact and surface cleanliness are very important when joining thick sections. Oil, grease, dirt, mill scale, etc. must be removed if optimum results are to be expected. When clean thickness of the front piece is limited to approximately 0.125 in. for mild and stainless steel.

In general, the thicker the material being welded, the greater the required joint strength. As thickness increases, current and weld-time adjustments can be made to produce spots of increasing strength. However, after thickness of the front piece exceeds approximately 0.060 in., joint strength cannot be increased proportional to thickness. At approximately 0.094 in. the maximum weld diameter and depth of fusion are obtained. This condition is shown graphically in Fig. 4 for mild steel. For stainless steel the curve follows the same general trend up to approximately 0.080 in. and then falls off somewhat more rapidly because of the lower thermal conductivity

of stainless, which makes depth of fusion more difficult to obtain.

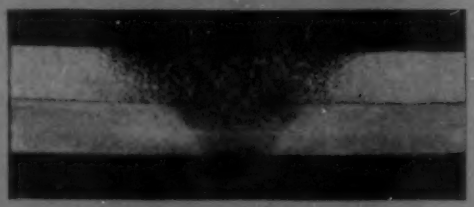
ARC LENGTH – Increasing arc length affects the size, shape and strength of the weld. It has somewhat the same effect as if welding time is increased and the current is reduced. It results in an increase in surface diameter of the weld and decrease in depth of fusion into the back piece, as shown in Fig. 5. Operating conditions which will produce satisfactory welds with an 0.062 in. arc length, for example, will produce little or no depth of fusion when the arc length is increased to 0.094 in. Excessive arc lengths may also produce radial cracks in the surface of welds made in some stainless steels. Reduction in arc length much below 0.062 in. may cause misfiring or freezing of the electrode to the work.

CURRENT – The primary effect of increasing current (when both pieces are of approximately the same thickness) is to increase the depth of fusion. In doing so, however, the weld diameter increases somewhat as shown by the dotted line in the left illustration of Fig. 6. Increasing the current when the back piece is considerably heavier than the front piece will result in an increase in weld diameter with little or no increase in depth of fusion, as shown at right in Fig. 6.

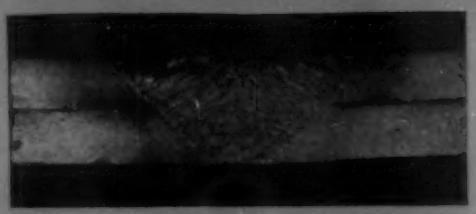
Table II—Weld Sections Obtained Under Typical and Ideal Conditions

Effect of Shielding Gas On Weld Section

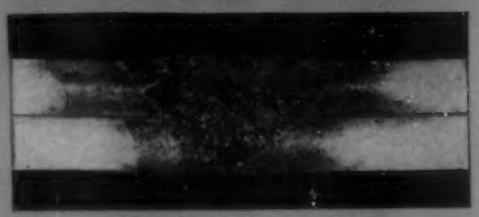
Material was cold rolled steel, 0.038 in. front and back pieces, with no backing. A 3/32 in. thoriated tungsten electrode was used and set for a 1/16 in. arc length.



Gas: Helium
Current: 100 amp
Time: 1/6 sec (10 cycles)



Gas: 65/35 Per Cent Helium-Argon mixture
Current: 125 amp
Time: 1/6 sec (10 cycles)



Gas: Argon
Current: 125 amp
Time: 1/3 sec (20 cycles)

Effect of Post Heat and Extreme Care In Control of Variables On Weld Quality

Material was type 321 stainless steel. Front piece was 0.050 in. thick; back piece 0.038 in. A 3/32 in. electrode was employed.

Gas: 71/29 Per Cent Helium-Argon
Welding Current: 95 amp
Welding Time: 2½ sec (150 cycles)
Post heat Current: 15-20 amp
Post heat Time: 2½ sec. (150 cycles)
Controlled Gas Backing—Helium
Average Breaking Load—1650 lb

WELD TIME–Increasing of weld time increases weld diameter. However, penetration also increases but to a lesser extent, much the same as shown by the dotted line in the right illustration of Fig. 6.

SHIELDING GAS–Heliumwill produce greater depth of fusion than argon; argon will produce larger weld diameter than helium as shown by the illustration in Table II. For joining two pieces of stainless steel, where both pieces are less than 0.060 in. thick, without backing, and lighter sections of mild steel (0.030 in. or less), without backing, argon is generally recommended. This is because helium, with its deep depth-of-fusion pattern will penetrate through the thin back piece before sufficient diameter is obtained to develop required strength. It takes much more current to achieve the same penetration when a backing plate is used. Therefore, helium is recommended instead of argon when these materials are backed up. Consistent results are generally harder to obtain with argon than with helium when backing is used, so helium should be used whenever practicable. For certain high-quality applications on light-gauge stainless steel, a helium-argon mixture produces best results. Such a mixture in the ratio of 2 to 1 will produce a weld section approximately half way between the cross sections shown for helium and argon in Table II. The

depth of fusion will be somewhat less and weld diameter will be greater than shown for helium.

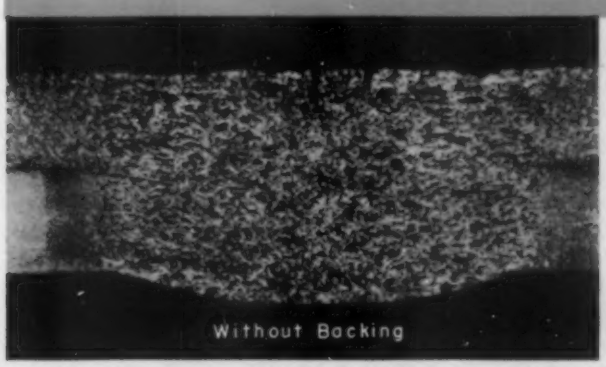
EFFECT OF BACK SUPPORT—Welding from one side can be done without back support provided the sections are sufficiently stiff to withstand the pressure applied by the operator when pressing the gun against the work. For thin sections, some back support will usually he required. Either steel or copper backing may be used. Also, the support may be directly behind the weld, or may surround it, leaving the point of weld exposed. Welding conditions vary depending upon the material of the backing plate and its location. A joint with backing directly behind it will require more heat than one either without backing or where the support surrounds the point of weld. When steel is used for the backing, particularly when all surfaces are clean and the backing plate is relatively thin, excessive penetration can occur and weld the pieces to the backing plate. Copper backing is therefore preferred; because in addition to providing support for the parts to be joined, higher heat input is possible resulting in stronger welds without excess depth of fusion. The advantage of using copper backing is shown in Fig. 7 for two thicknesses of 0.038 in. cold rolled steel.

SURFACE CONTACT AND CLEANLINESS—Because of the way heat is applied, any factor which tends to decrease heat transfer into the back piece will also decrease the depth of fusion and thereby reduce joint sterngth. Mill scale, oil, grease, dirt, paint and other foreign materials on or between the contacting surfaces will prevent good contact and reduce the weld strength. If sheared materials are used, the resultant burr can prevent the making of a good weld if the burr is located such as to prevent good contact between the two pieces at the point of weld. The effect of poor contact on weld cross-section is shown in Fig. 8.

With clean surfaces and good surface contact, the weld contour will be approximately as shown at Fig. 8 (A). If the contacting surfaces are separated slightly by foreign materials, the weld section will appear approximately as shown at (B). The break between the two contacting

Table II—Shielding Gas vs Condition of Material

Material	Condition	Gas Recommended	Explanation
Stainless Steel	Top piece 0.060 in. or less; bottom piece approx. same or thinner. No backing.	Argon	Too great a penetration may occur using helium before the diameter is large enough to give required joint strength. Also, less susceptability to cracking with argon.
	All sheet, with backing.	Helium or argon	Less penetration with backing for same diameter of weld.
Mild Steel	Light sections, without backing.	Argon	Same as for stainless, without backing.
	Light sections, with backing.	Helium or helium-argon mixture	Same as for stainless, with backing.
All Other	Any	Helium	



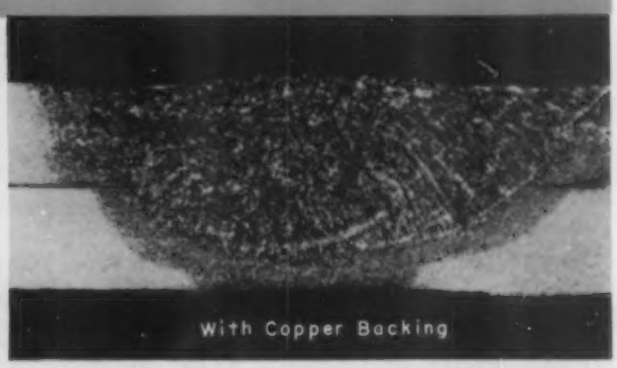


Fig. 7—Weld cross-sections showing effect of copper backing. Both welds were on 0.038 in. cold rolled steel with 125 amps in 1/3 sec (20 cycle setting on Timer). Note the reduced depth of fusion obtained with backing at right. By increasing the current, the weld strength with copper backing will equal that of the unsupported weld without producing the excessive penetration evident at left.

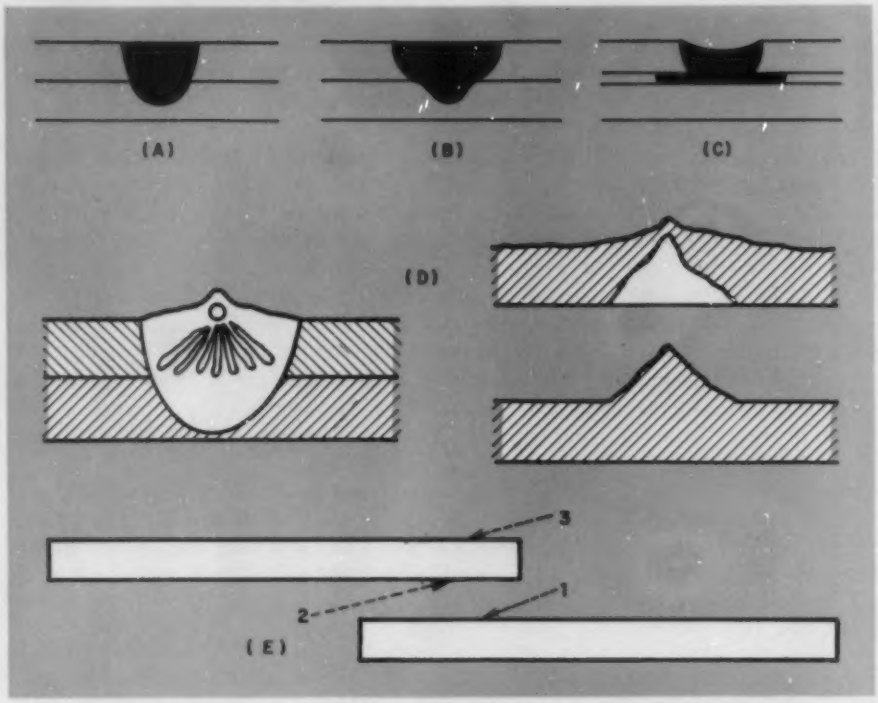


Fig. 8—Good surface contact is important in obtaining a good weld; mechanical contact is necessary, and the surfaces must be clean. (A) Weld obtained with good surface contact. (B) Weld where contacting surfaces are slightly separated by oil, dirt or other foreign matter; the "necking down" of the weld reduces effective weld diameter and joint strength. (C) No weld took place because of poor contact. (D) Appearance of weld in hot-rolled steel having a tight mill scale; the "puff up" is caused by gases released by heat of welding, and when such a joint is loaded in shear the weld will fail as shown in the right illustration. (E) Removing scale from surface (1) may improve the weld on light gages of material—removal from surfaces (1) and (2) may suffice for all but the heaviest thickness—for 0.094 in. and heavier, scale should be removed from all surfaces (1), (2) and (3).

surfaces acts as a barrier to heat transfer, making it difficult for the weld to "break through" into the back piece. The resultant "necking down" of the weld cross-section reduces the effective weld diameter and also reduces joint strength. Unfortunately, however, the surface appearance will be practically the same as that of a weld which has proper depth of fusion. The surface diameter of weld (B) may actually be slightly larger than that for weld (A) but should not be interpreted as an indication of a larger and therefore stronger weld. Sometimes satisfactory welds can be made if sufficient heat is provided to penetrate this surface barrier.

If contact between the two parts is very poor, there will be no heat transfer into the back piece, and the molten metal will spread out between the two parts as shown at Fig. 8 (C). This condition can generally be recognized, because the surface of the spot will usually be concave as shown.

Mill scale on hot rolled steel acts as a heat barrier. This mill scale also affects the weld quality. Welds made in hot rolled steel having a tight mill scale will usually "puff up" and the surface of the weld will have a shiny, glossy surface. There also may be a slight bump at the top of the weld. The cross-section of such a weld will generally appear as shown in the left sketch of Fig. 8 (D). Removal of the scale from surface "A", as shown at (E), will be of some benefit when making welds in the lighter gages. Removal of the scale from both surfaces "A" and "B" will in most cases be satisfactory for all but the heavier thicknesses. For material in the range of approximately 0.094 in. and heavier, the scale should be removed from surfaces "A", "B", and "C".

The cost of removing the scale is a factor which cannot be overlooked. However, a check should be made to ascertain that cost of scale removal is more than savings that may accrue by this welding method before the process is discarded. Hot rolled steel, pickled and oiled, generally can be welded satisfactorily. In some cases, sufficient advantage is obtained by welding from one side to warrant the use of cold rolled steel in preference to hot rolled.

STANDARDS AND TEST PROCEDURES

Since welding from one side is a new process, complete specifications for strength requirements or design factors are not yet established. As a result, tests to establish welding procedures have been made in accordance with specifications established for resistance spot welds. Coupons have been prepared for testing in unrestricted shear to determine the ultimate strength of the joint. Where this is impossible, coupons can be given the "peel test." By pulling the front piece directly over the back piece, a button will be pulled if the weld is satisfactory. By these tests, evidence shows that welds can be obtained of equal or greater strength with present equipment available for welding from one side as can be obtained with the usual resistance spot-welding equipment in general use.

Of particular interest are the requirements on weld diameter to achieve required joint strength. In Fig. 9, breaking load is plotted against nugget diameter for mild steel using various shielding gases. A horizontal line at 930 lbs indicates the minimum allowable load for joining two thicknesses of 0.038 in. material according to resistance spot welding recommendations. The vertical line at 0.195 in. is the approximate weld button diameter required, based on information taken from the Welding Handbook. Thus, to be acceptable, welds should be above the 930 lb line and to the right of the 0.195 line—that is, in the upper right-hand corner of the graph.

Whenever a weld broke at less than the required load, the weld diameter was below the specifications requirements; however, with less than specified diameter, welds often did not break until greater loads were applied than

that required. The conclusion is that welds can be produced with a relatively high current and low time cycle to speed operations and still produce the required strength; also, that if a diameter is specified, this diameter can be produced with a strength closely approximating spot welding specifications. Another interesting fact is that welds made by joining 0.038 in. material to thicker material produced considerably higher strength with less weld diameter than when two pieces of the same thickness were joined.

APPLICATIONS

Welding from one side of the work should be considered in light-gauge metal fabrication, particularly for lap joints which would be difficult to get at from both sides or where the location of the weld or size of parts makes resistance spot-welding difficult. Also, it can be used where present design does not call for spot welding because the small number of welds which would be required would not justify the investment in large resistance spot-welding equipment. It can also replace other joining methods such as plug welding or riveting where it will speed production and effect economies.

One-side spot welding of the 0.062 in. thick top side of a 304 stainless steel meat tray to 0.125 in. stainless bracing underneath is shown in Fig. 1. Spot welds are made without any indentation. This meat tray formerly required jigs, fixtures, and considerable handling time, as well as tack welds on the under side.

By eliminating jigs and fixtures and reducing the amount of finishing work on the product, production of meat trays has been stepped up from 21 to 30 per hour. Another example is a component for an air conditioning unit shown at (A) in Fig. 10. Approximately 170,000 spot welds with one gun have been made on units of this type.

By changing the joint design on an industrial cabinet to take advantage of the process, production was stepped up from four to over 36 per day. The old procedure on the double-face cabinet door was to press the pieces of metal together and then seam weld the inside corner 1½ to 2 in. on a 90 deg angle (all four corners). The build-up on the weld zone was from 0.094 in. to 0.125 in. and had to be ground off and polished. The job is now being done by one-side spot welding along the edge of the door as shown at (B) in Fig. 10. Joint design was changed by increasing the size of the flange, installing a replaceable panel, and by utilizing corner reinforcements and reinforcement bars. All material used is stainless in thicknesses of 0.070 in., 0.062 in., and 0.050 in.

The redesign simplified assembly and reduced jigging time. Formerly it took six men 8 hr to form, assemble, and complete a cabinet; now it is done with three men in 4 hr.

As a secondary tool, the process can be used with other joining methods for tack welding prior to final assembly; for example, to tack-weld the flange to a cylinder in the production of blower housings. These housings, made of

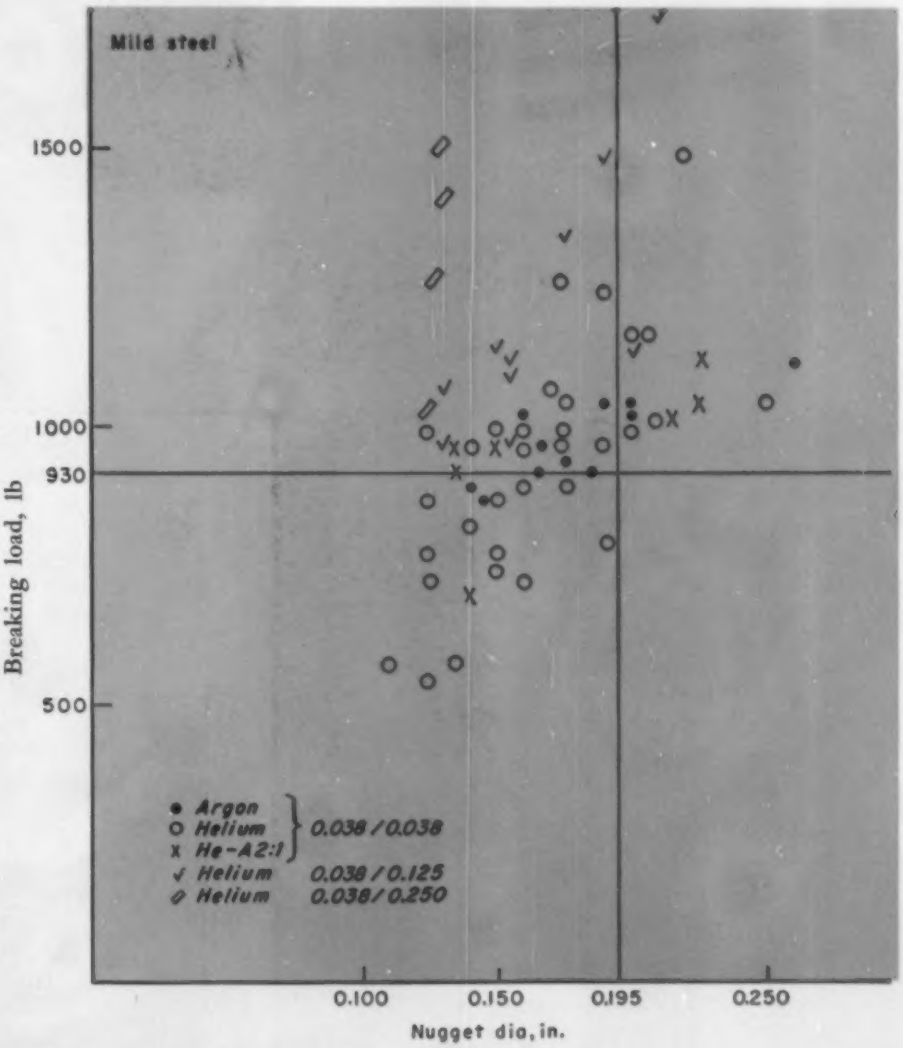


Fig. 9—Effect of weld diameter on breaking load is shown for lap welds on mild steel. Coupons were tested for various gas mixtures. Most tests were on 0.038-to-0.038 in. material, but helium was also used on 0.038-to-0.125 in. and 0.038-to-0.250 in. material to show effect of thickness on failure point. Based on resistance spotwelding standards, acceptable welds should be above the 930 lb line and to the right of 0.195 dia. The large number of points above the 930 lb line but left of 0.195 dia indicates that welds of sufficient strength can be obtained with somewhat less than specification diameter.

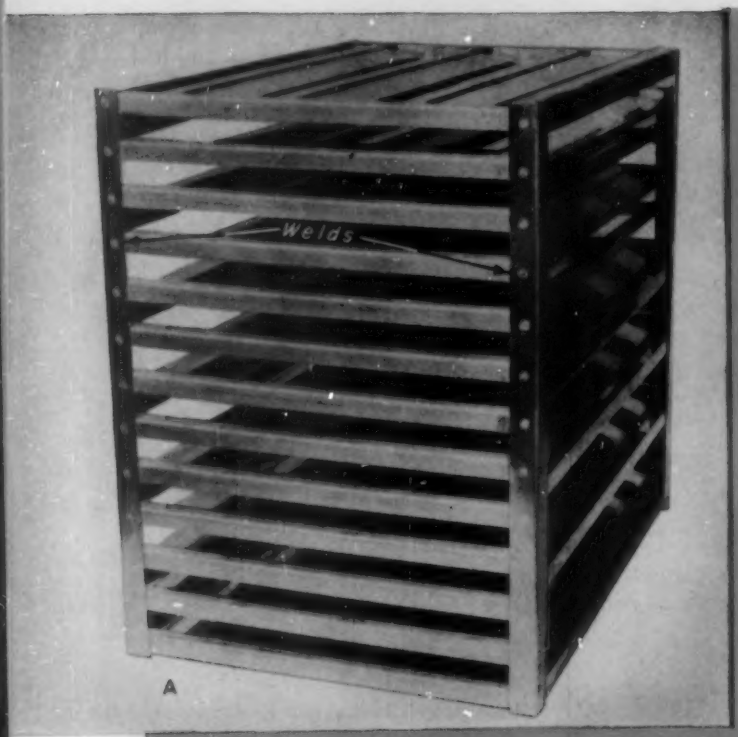
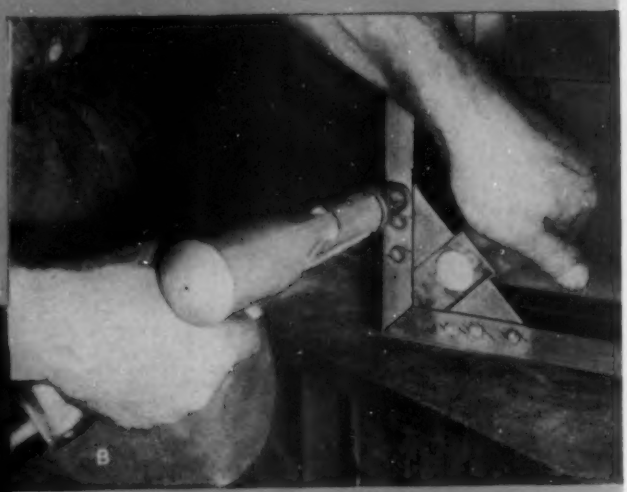


Fig. 10—Applications for spot-welding from one side. (A) Welds on a component for an air conditioning unit which did not lend itself to resistance spot welding. (B) A corner joint on an industrial cabinet was redesigned for one-side spot welding and increased production nine fold; as originally designed, the build-up caused by seam welding the inside corner had to be ground off and polished. (C) Tack welding to hold pieces in place while assembling or joining by other means. In the production of blower housings, a flange is tack welded to a cylinder in preparation for arc welding. By eliminating jigs and fixtures, fabrication time was reduced 80 per cent. (D) Welding the steel top of a large display cabinet; this is an example where much difficulty and loss of time would result if the work had to be moved into position for resistance spot welding.



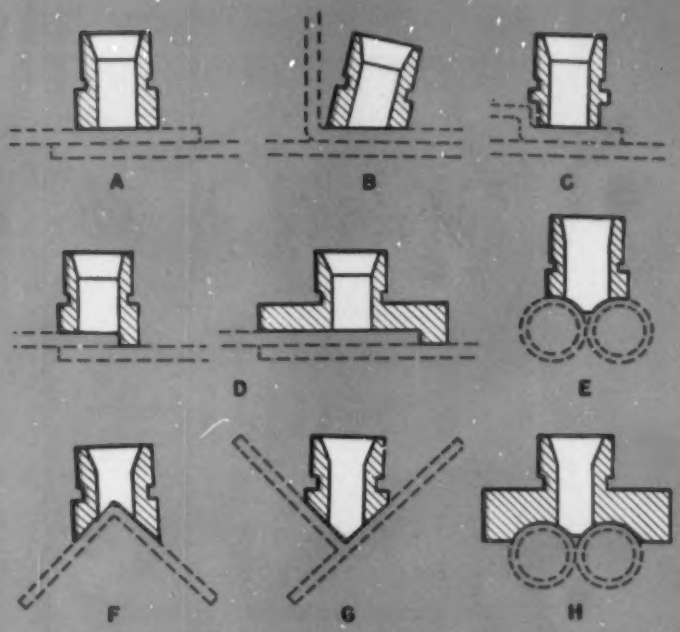
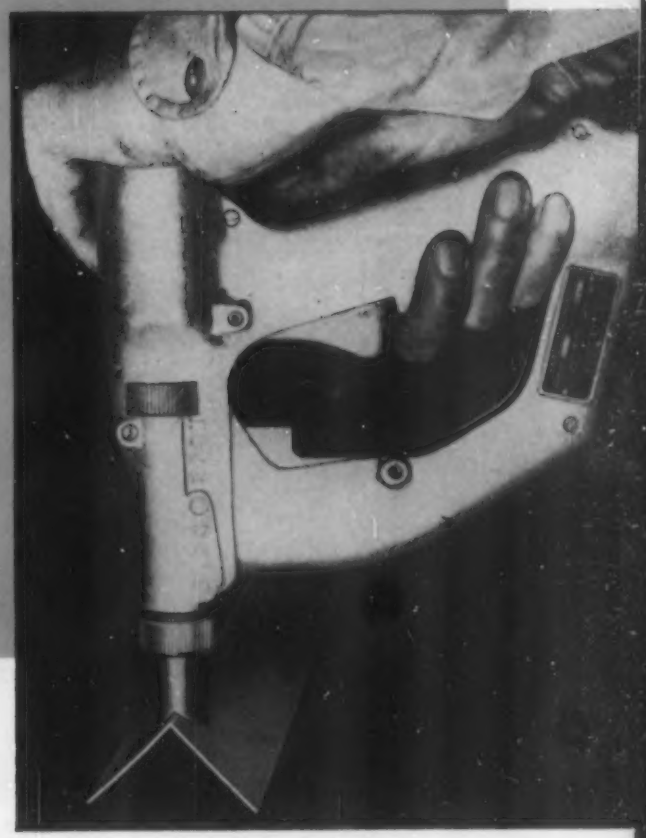


Fig. 11—Nozzle configurations may be varied in shape to fit different welding requirements. (A) General-purpose. (B) For tight corners. (C) For making welds on items such as small holding clips. (D) For accurate location of welds from the edge of a joint. (E) For tack welds between two parallel tubes. (F) For tack welds in a corner joint. (G) For inside tack welds in a Tee joint. (H) For joining parallel tubes while holding them together.

Fig. 12—Using a modified nozzle to tack weld a 90 deg outside joint. Uniform location of multiple welds is assured without expensive jigs and fixtures.



0.062 in. S.A.E. 1010 mild steel, are tacked as shown at (C) in Fig. 10 for subsequent arc welding. The fabrication time has been reduced from 17 min to 3 min on each blower housing by eliminating jigs and fixtures formerly required to align the parts for welding. The large display cabinet shown at (D) is another application. The operator is welding the 0.062-in. mild steel top of the cabinet to the inside structural members which are made of 0.094 in. material. Weld spacing is about 3 in.

MODIFIED AND SPECIAL GUN NOZZLES EXTEND APPLICATIONS

A standard copper nozzle can be used for most applications. It can be modified, however, and special nozzles can be built to suit many joint types. Some nozzle shapes which can be employed are shown in Fig. 11 and can extend the versatility and effectiveness of the process. A close-up of a modified nozzle applied to a 90 deg outside joint for a tack spot weld is shown in Fig. 12. Aside from allowing a weld to be made in a tight corner, nozzles can be shaped to serve as locating tools, thus assuring uniform positioning of spots without use of jigs and fixtures.

SUMMARY

Spot-welding from one side should generally be considered as a supplementary process to other welding, soldering and joining methods. For instance, it may well be used on a job alongside other joining processes, either to tack weld for locating a part prior to resistance spot-welding, seam welding, riveting, drilling, etc., or to do a joining job more easily or economically than by other methods. Sometimes it may seem desirable to redesign a job to use this method of joining exclusively. However, it will probably pay off most when the design is studied for its use at points where it is clearly a more logical tool than others available.

EDITOR'S NOTE—This is one of a continuing series of articles and covers in detail the use and application of the lightweight d-c powered gun mentioned in "A Progress Report on Shielded-Tungsten Arc Welding" on page 170 of the Feb. 1954 issue of *Product Engineering*. In the earlier article, the shielded-tungsten arc—or Heliweld process was described; it centered primarily around seam welding, rather than spot welding. Many factors peculiar to Heliweld are nevertheless also applicable to inert-gas spot welding; and it is therefore suggested that this earlier article be considered along with the current one.

The strength data for spot welded joints in titanium and stainless given in the article "Strength of Titanium Spot Welded Joints" on page 193 of July 1954 *Product Engineering*, should be useful as a guide in design for inert-gas one-side spot welding of titanium and stainless-steel sheet.

Fig. 1—Hand brushing is one way of applying finishes when the part does not lend itself to multiple production processing. This aluminum boat is being treated with a dilute phosphoric acid solution before being painted.

Phosphate Finishes

Chemical reaction with a natural or artificial environment changes the surface of a metal to an insoluble oxide, phosphate, or other salt which remains as a coating. Cleaning without modification of the metal is often employed and optimum paint life and metal preservation is obtained when the surface undergoes a complete transformation and becomes nonmetallic.

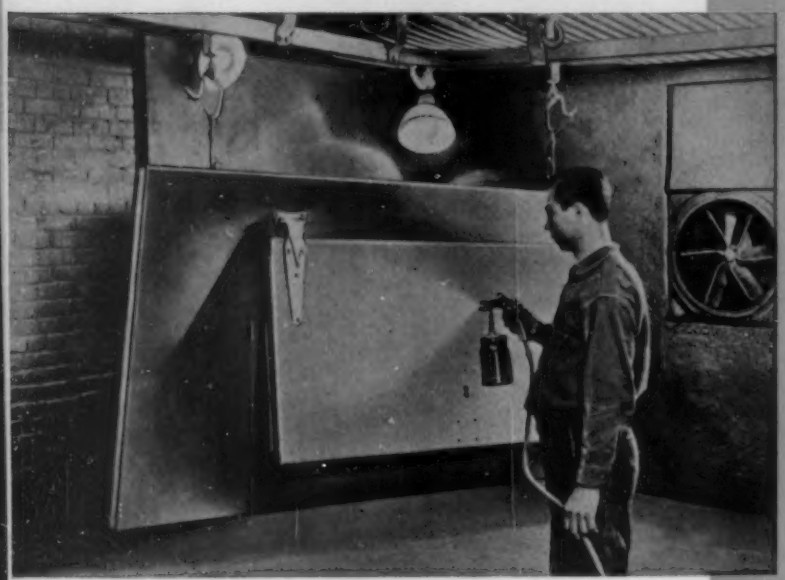


Fig. 2—This freezer cover is being coated with zinc-iron phosphate by hand spraying for improved paint adhesion.

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IF METAL SURFACES are not physically and chemically clean, adhesion of subsequently applied paint films will be poor, leading to early failure in service. It is important that all oil, grease, dirt, and chips be removed from the surface and that all rust and other corrosion products be removed to obtain optimum paint life. An organic finish can be obtained with precise regularity, provided that certain principles are observed.

First, the metal surface to be painted must be chemically and physically clean. Second, the clean metal must present a homogeneous surface to which paint will adhere firmly and which will prevent the spread of corrosion underneath the paint film from an accidental break in that film.

Rust-stimulating ions such as chlorides and sulfates, alkali residues, and thin oil films which are frequently invisible, will cause premature paint failure. The presence of one or more contaminants—oils, drawing compounds, alkaline salts or scale,—is enough to destroy high quality paint finishes and reduce corrosion resistance.

The Preparation of Metal Surfaces for Paint

Preparing metal for paint falls into two general categories—mechanical and chemical. Generally, mechanical preparation of metal surfaces is uneconomical and unsatisfactory. Shot and sand blasting, scraping and sandpapering are examples of mechanical cleaning. Bits of scale, rust, oil and rust stimulators are driven into the surface of the metal, resulting in poor adhesion and early paint failure. Although mechanical cleaning is widely accepted on outdoor structures, supplemental chemical treatments, if employed would provide a basis for maximum paint adhesion and paint life.

Chemical treatments can be divided into three general groups: cleaning without reaction with the metal surface, cleaning with surface modification, and cleaning with surface conversion.

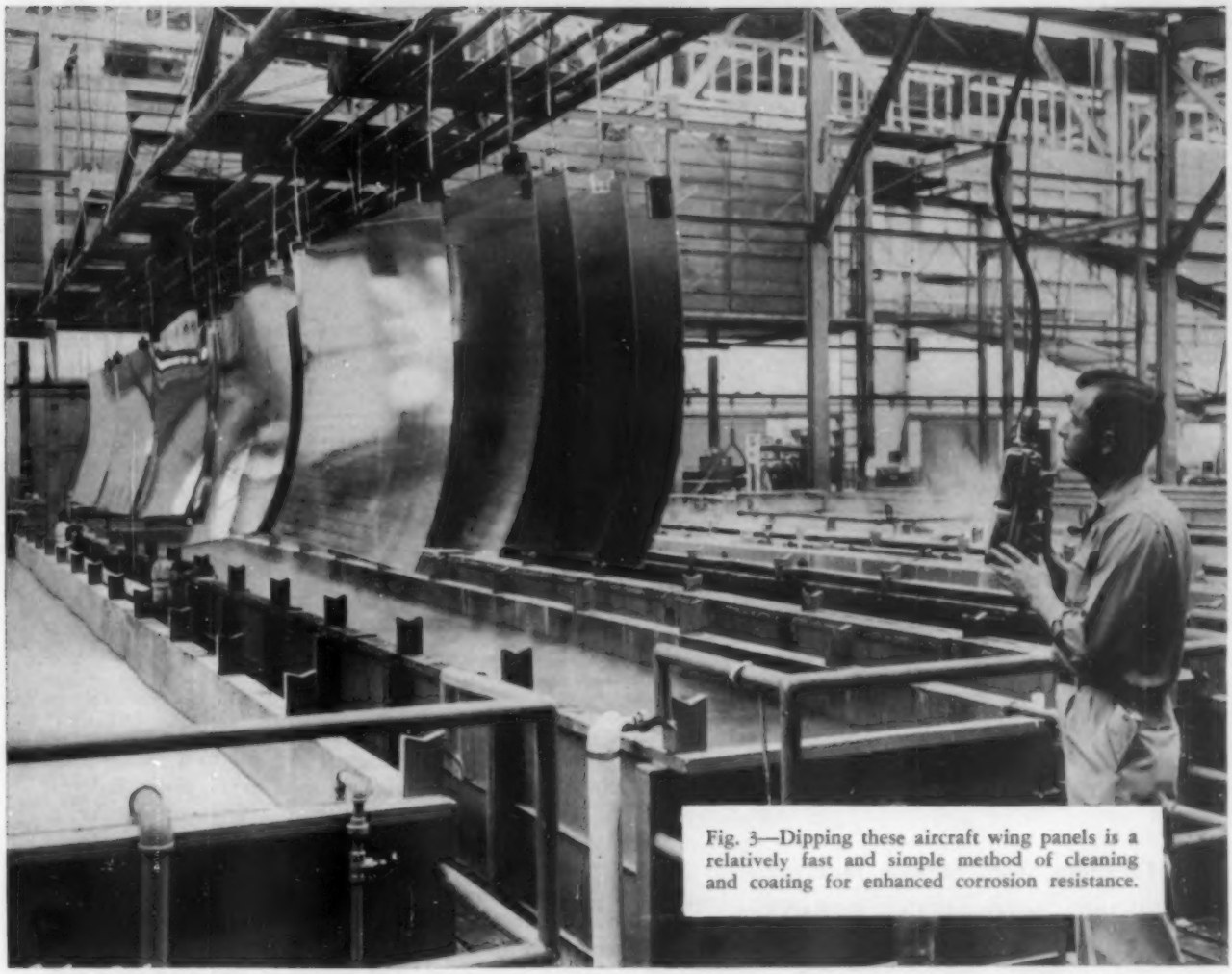

Fig. 3—Dipping these aircraft wing panels is a relatively fast and simple method of cleaning and coating for enhanced corrosion resistance.

Cleaning Without Surface Conversion Or Modification

ALKALI CLEANING. Alkaline cleaners provide good results in removing surface contaminants such as, grease, oil, fingerprints and other corrosive salts, shop dirt and dust at a low chemical cost. There is this disadvantage—any alkali remaining on the surface of the rinsed metal will cause poor adhesion and possible early paint failure. This can be overcome by rinsing the cleaned parts in a dilute phosphoric or chromic acid solution.

There are several advantages in the use of alkaline cleaners. They are highly effective, remove oil and greases readily as well as soluble rust stimulators. Alkali cleaning is economical and these cleaning solutions are free of poisonous fumes.

SOLVENT CLEANING. This method consists of dipping or swabbing the metal parts with petroleum and paint solvents. Solvent cleaning creates a fire hazard, is relatively expensive in material and labor; and, unless clean solvent is used, a film of oil is left on the metal. Rust, rust stimulating salts and other water-soluble materials, however, not removed and this constitutes a disadvantage of the method.

VAPOR DEGREASING. Vaporized chlorinated solvents such as trichlorethylene are allowed to condense on the metal, thus washing off all grease and oil. Vapor degreasing is frequently used to supplement other types of cleaning. Perhaps the most valuable single feature of this method is that the work leaves the machine in the vapor phase and is then washed with pure liquid solvent that condenses on the metal surface. The work is cleaned with uncontaminated cleaning solution and since it is heated to vapor temperature, quickly dries by evaporation before leaving the machine.

As in solvent cleaning, water soluble salts which stimulate rust are not removed and chlorides from the slight decomposition of the solvent are deposited on the surface causing accelerated corrosion of the metal. The vapors of the chlorinated solvents are quite toxic, necessitating

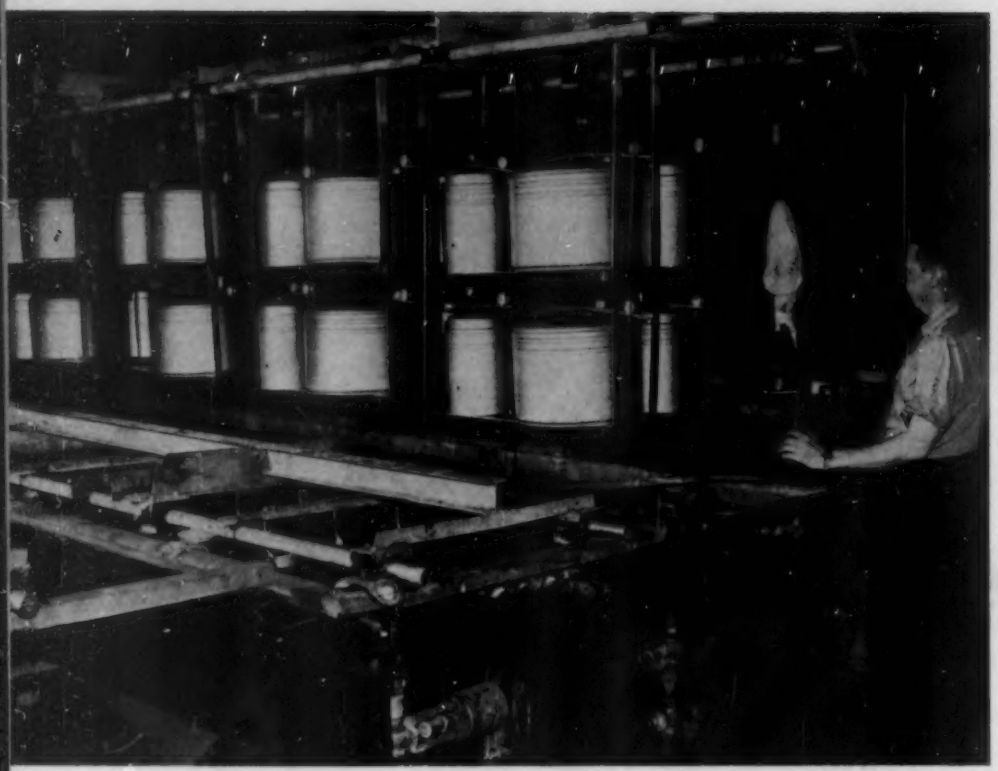

Fig. 4—Immersion on racks speeds up coating procedures. Here are aluminum containers going through the phosphatizing process prior to receiving final surface treatment.

constant observance of safety precautions, and the cost of cleaning by this method may be higher than of other types.

Cleaning With Surface Modification

PHOSPHORIC ACID METAL CLEANERS. Phosphoric acid rust removers and metal cleaners for cleaning steel, iron, aluminum, brass, copper and other metals correctly for painting, are available in a large variety of grades. They are combinations of grease solvents, phosphoric acid and water in various combinations. Their functions include: removing oil and light heat scale, eradicating rust, neutralizing rust producers and creating an etched, inert surface prepared for bonding a paint to metal. The cleaners are used diluted in acid resisting equipment such as lead, stainless steel, or rubber. There are three main types available, depending on whether a brush, dip, or spray process is to be used.

If production is small or infrequent, and the parts to be treated are too large to be immersed conveniently in a tank, the best way to apply phosphoric acid metal cleaners is by brushing. If production is medium or large, and the parts can be treated conveniently in a tank, phosphoric acid metal cleaners can be applied by immersing the parts, either individually or on racks.

If production is large and continuous, and the parts can be conveniently carried on a mechanized conveyor through a power spray washing machine, application by spray is most economical and satisfactory. Spray types are emulsion type acid cleaners and can be used effectively at temperatures up to 140 F, the solution's chemical cleaning action being augmented by its impingement under pressure on the metal surface.

The phosphoric acid metal cleaners etch the metal slightly but do not add a perceptible coating to its surface. For extra protection to both paint and metal, it is customary to change the character of the metal surface by chemically converting it into a non-metallic and therefore an inert material.

Cleaning With Surface Conversion

It is standard practice today to coat automobile bodies with zinc phosphate for better paint adhesion, to coat pistons and piston rings with manganese phosphate for protection of the rubbing surfaces, to coat aluminum with amorphous phosphate, or mixed chromates and oxides for improved corrosion-resistance and improved paint adhesion.

When a metallic surface is exposed to a corrosive environment, solution of the metal takes place, resulting in corrosion products which have a decisive influence on the subsequent course of the disintegration process. If the corrosion products are soluble, thereby forming a non-adherent, scale-like coating, the attack continues. If the corrosion products precipitate on the surface of the metal and form an insoluble, adherent film, further attack is retarded or stopped. The rusting of iron produces a non-adherent scale, while the ever-present oxide film on aluminum gives a considerable degree of protection to this metal.

Description of Phosphate Finishes

The natural formation of an insoluble protective film has been imitated under controlled conditions. A thicker, even more protective oxide film, is produced on aluminum by chemical or electro-chemical treatment, and iron and steel may be given an adherent oxide coating by proper treatment in salt baths. Phosphate coatings are produced in a similar manner. On immersion in the phosphatizing solution, the metal goes into solution and causes precipitation of a coat of fine crystals of secondary and tertiary phosphates. The formation of these surface conversion coatings may be considered a form of controlled corrosion. During the formation of such coatings the metal dissolves. The dissolved metal combines with one or more constituents of the treating solution and, together with other constituents of the bath which have become insoluble because of the shift in equilibrium caused by the dissolving metal, precipitates at the surface in the form of a coating

which may inhibit further disintegration.

The corrosion protection given to metals by such coatings is usually limited. To increase their protective value, the coated surfaces are given a sealing treatment or are used as a base for additional coatings of oil, painting, shellac, lacquer, stains, and other organic finishes. Excellent absorption of these finishes in the pores of surface phosphate coatings creates an efficient bond between the metallic surface and the outer finish. The most frequently phosphatized metals are iron and steel, zinc, and cadmium. Phosphate coatings may be used as a base for an additional finish to inhibit corrosion, to reduce wear, as an aid to lubrication, or a lubricant carrier during extruding and drawing operations.

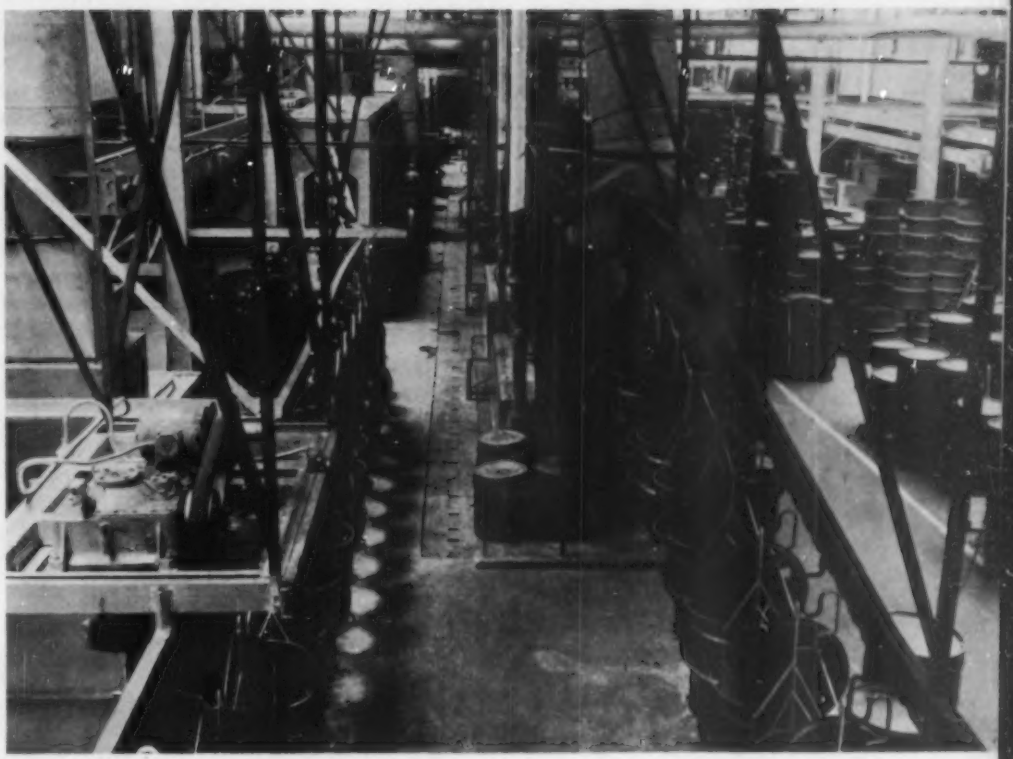

Fig. 5—Parts can be cleaned, rinsed, and coated by continuous conveyor systems. Steel drums and covers are being coated with iron phosphate on all surfaces for complete protection.

Metals are given phosphate coatings by subjecting them to a dilute, aqueous solution containing one or more primary phosphates of zinc, iron or manganese, phosphoric acid, and various types of accelerators. Coatings are produced either by immersion in this solution, by spraying in a power washer or by brushing for periods varying from 1 to 30 min. The time required for treatment depends on the thickness of coating desired, the temperature of the solution, the accelerating methods, and the method of application of the solution used.

Properties of Phosphate Finishes

The properties of the coatings are determined by the composition of the solution and the method of cleaning used in preparation for phosphatization. Cleaning is sometimes followed by a pre-treatment in order to activate the surface for phosphatization. After coating and rinsing the surface, it may be given a final rinse treatment in a dilute phosphoric or chromic acid solution to increase its corrosion-resistance. The steps in the complete process are cleaning, rinsing, pre-treating, phosphatizing, rinsing, rinse in dilute phosphoric or chromic acid, drying. Use of phosphatization on assembly lines was made possible by the development of a continuous spray method to produce paint-bonding coatings. The articles to be coated, such as automobile fenders, doors, and other large parts, move through a series of spraying chambers.

Except when phosphate coatings are to be used for wear resistance, the most desirable coatings are those having fine grain structure and smooth texture. Coatings vary in thickness from layers of undeveloped crystals applied to 1 to 5 min for paint bonding, to thick blankets of crystals used to increase corrosion resistance or to reduce wear. To form the latter required 10 to 30 min exposure to the phosphatizing solution. By varying the composition (accelerators), operating conditions (acid ratio and point strength), and the method of application, all of these coatings may be produced.

The composition, structure, and the properties of coatings produced in low temperature solutions are equal to those formed in solutions operating at near-boiling temperatures. However, the treatment time required to produce equivalent properties with low temperature solutions is somewhat longer. Because the coating action depends only on contact between the solution and the metallic surface and is not dependent on an electric current, objects of irregular contour are coated as efficiently as flat sheets.

Coating a metallic surface with a layer of fine crystals of phosphates creates a new surface having completely different properties but remaining an integral part of the basis metal. The surface becomes largely non-metallic, electrically non-conducting, enlarged in specific area, and more porous and absorbent. The metal itself remains unchanged in hardness, tensile strength, elasticity, and magnetic properties. For a medium heavy coating, the dimensional change on phosphatization is an increase of about 0.005 cm (about 0.002 in). This is not, however, the actual thickness of the coating. During phosphatization the metal first dissolves before the coating builds up. Therefore, the thickness of the layer of crystals is greater than a measurement of change in dimension indicates. Cross-sectioning and optical examination of a coating sheet reveals that the actual thickness of a medium heavy coating to be about 0.005 cm.

Phosphate coatings formed in zinc phosphate solutions

may be heated to about 300 C without any visible change taking place. When heated above this temperature, the coating changes in color from gray-black to dull black, velvety, dark red, and dark blue. At about 400 C, the coating begins to peel in flakes leaving a silver, metallic surface.

For good corrosion resistance, objects are given coatings of medium thickness. To increase this resistance further, aluminum surfaces, after rinsing, are exposed to a sealing solution which contains chromate or dichromate compounds. Chromates are powerful inhibitors for iron, their protective action, however, is dependent upon a continuous supply of chromates. For this reason the protective value of chromate sealing treatments on phosphate coatings is only temporary and further protection is required. Objects, usually tools and machine parts, treated in this way are dipped in oil to give a more permanent type of protection. Black coatings are obtained by adding coloring matter to oil.

The large specific surface and porosity of even thin phosphate coatings make them excellent bonding agents for paints and other finishes used on metals. By increasing the surface area adhesion, wetting and absorption is enhanced, while the irregularities of the crystalline coatings, pores and cavities increase the mechanical adhesion.

Thin coatings formed in a few seconds of spraying suffice to produce these effects. When a finish, bonded to the metal by a phosphate coating is scratched down to the metal itself and exposed to a corrosive environment, the destructive attack is largely confined to the scratch. There is little peeling caused by progressive attack under the finish.

Thick, relatively coarse manganese phosphate coatings are used to reduce wear. Such coatings have been found to increase the sufficing load on gears to more than twice that for an untreated impregnated phosphate layer. When phosphate coatings are used to reduce wear, metal-to-metal contact is prevented and the coating may act as a reservoir for oil. After the coating has worn off, a rough surface remains which continues to act as a reservoir for oil, and at the same time, provides an escape for wear particles. The electrical insulating properties of phosphate coatings are useful in the insulation of magnetic sheets.

Fig. 6—Aluminum strip undergoing continuous surface treatment prior to being painted.

Phosphates Used for Industrial Finishes

Zinc-iron phosphate is an excellent finish for pre-paint systems and is used to give heavy coatings to metals. It can be applied by hand or power spray, brush, dip or flow. Application is usually preceded by emulsion-alkali cleaning. This material has a coating weight range of 100 to 600 milligrams per sq. ft. and is used on steel, iron, or zinc parts such as automobile bodies, refrigerators, washing machines, and ordnance equipment.

Manganese-iron phosphate gives a heavy jet black coating which is used on friction surfaces to improve wear and rust resistance. This material is applied by dipping in immersion tanks. Typical metal products treated include friction surfaces such as pistons, piston rings, gears, cylinder liners, cornshafts, tappets, crankshafts and rocker arms. It has a coating weight range of 1,000 to 4,000 mg per sq ft and can be used on chillfaced or nitrided surfaces. Pre-cleaning for this system can be effected by any degreasing method. Acid cleaning, alkali cleaning and emulsion-alkali cleaning may need to follow other cleaning methods if rust or scale is present on the part.

Iron phosphate is a fairly new development which puts a light coating on surfaces. Cleaning and coating occur in the same bath and the system normally operates in 3-stage equipment. It is generally used as a pre-paint coating for improved paint adhesion. It is applied by power spray equipment and has a coating weight range of 50-100 mg per sq ft. Typical uses for iron phosphate coating are iron or steel fabricated units such as refrigerators, kitchen cabinets and washing machines.

Zinc-iron phosphate is a relatively heavy phosphate coating generally used for rust proofing applications such as hardware, tools, guns and cartridge clips. It is applied by dip or barrel tumbling. Pre-cleaning of the part can be effected by any of the common degreasing methods using acid, alkali or emulsion-alkali cleaning agents. Acid cleaning may need to follow other cleaning methods if rust or scale is present. Zinc-iron phosphate has a coating range of 1,000 to 4,000 mg per sq ft.

There is a zinc-iron phosphate coating used with a suitable lubricant to facilitate the cold mechanical deformation of steel. Typical applications for this material are in tube drawing operations, cold forming of blanks and shells and heavy stamping. This material is applied by dip or power spray and has a coating weight range of 150 to 3,000 mg per sq ft. Pre-cleaning can be effected by alkali or emulsion-alkali cleaners but the part must be pickled after annealing and before pre-cleaning begins.

EDITOR'S NOTE—The primary function of paint and other organic finishes is to protect the surface they cover. Of secondary, but almost equal importance, is the decorative value of such films. This article on the preparation of surfaces for paint will be followed by a description of the new paint systems and their specific applications. The two articles should provide a working background for coating products in use as well as those being designed.

PROPER SHAFT AND HOUSING FITS ARE NECESSARY TO:
1. MAINTAIN RADIAL AND AXIAL RIGIDITY
2. DEVELOP CALCULATED PRELOAD
3. REDUCE VIBRATION
4. REALIZE CALCULATED AVERAGE LIFE
5. CONTROL INTERNALLY GENERATED TEMPERATURE
6. PREVENT EXCESSIVE CREEP OF RINGS AND IRON OXIDE FORMATION
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Recently, New Departure Division, General Motors Corp., asked engineers in the machine tool industry to submit a list of questions they, as users, would like answered. Specialists at New Departure prepared answers to these questions—and presented them at the company-sponsored Ball Bearing Conference that was held in Hartford, Conn., on February 15 and 16.

Because many of the problems that were discussed are shared by *all* users of ball bearings, a selected list of these questions and answers are presented below. They cover such topics as noise and vibration, load and speed capacity, mounting fits, seals, and lubrication requirements and selection.

Answers to

17 Ball Bearing Problems

What has been done to reduce bearing noise and vibration at high speed?

Appreviable reduction in vibration and noise of precision bearings has been achieved by closer tolerances, better balls such as the Instrument Grade, and improved race finish. Instrument Grade balls within any single bearing are matched to within 0.00001 in. and are spherical within 0.000005 in. Manufacturing processes have been developed and are being improved to give improved geometry and closer tolerances, particularly in the raceways.

Dynamic balancing of the rotating parts is extremely important. For example, with a mass of 1.0 lb consisting of the shaft, bearings, and rotor which is revolving at 100,000 rpm, if the center of gravity is displaced from the center of rotation by 0.0001 in., there will be a force on the bearings of about 13 pounds. This, of course, would not only result in noise, but could shorten the life of the bearings. Experience indicates that high speed

rotation requires balancing to within 50 to 80 micro oz-in. to achieve satisfactory life and a low level of vibration and noise.

How does speed influence mounting fits?

Mounting fits should be based not only on the operating speed, but also on the load that the bearing is to carry, and to a certain degree, the mounting procedure.

For low speeds, moderate loads, and stationary housings, the inner bearing ring should be mounted on the shaft with an interference fit and the outer ring with a push fit in the housing. For such applications, fits recommended in manufacturers' catalogs generally are satisfactory.

With low speed but heavy load, a tighter fit between the shaft and bearing inner ring is recommended to prevent creep of the inner ring on the shaft. Also, the amount of permissible looseness between the bearing OD and the housing should be reduced.

Spindles designed for high speed operation are usually lightly loaded and mounted on bearings produced to ABEC 7 tolerances. The interference fit between the spindle and the inner ring should be as light as manufacturing tolerances will permit and the outer ring should be mounted with a push fit.

Should the same mounting fits be used for different housing materials?

If the housing is aluminum or other soft metal and bearing catalog fits are used, rotational creep of the outer ring may burnish the housing bore resulting in looser fits. Vibration accelerates this action and produces greater peening or wear. With light loading and smooth housing bores, bearings can sometimes be used without liners but tighter-than-normal fits are necessary. When loads are moderate to heavy or when the temperature range is appreciable, steel liners are necessary.

When a liner is necessary and space permits, a thick-walled liner is best. It can be pressed in, cast in or (when used as an adapter type) bolted on. Its thickness should be such that its bore will expand and contract at almost exactly the same rate as the bearing OD, thereby maintaining the original fit throughout the operating temperature range.

When space is limited, a pressed-in or cast-in thin-walled liner can be used. This is a liner whose thickness is less than the root thickness of the bearing outer ring, and which expands and contracts with the housing. Too tight a fit between a bearing and such a liner should be avoided to preclude exceeding the elastic limit of the housing. The resulting fit at one end of the range will necessarily be loose but the surface will not be as prone to damage from pounding because of the protection afforded by the liner.

What are the advantages of bearings which have one or both rings positively clamped compared to those located by snap rings?

It is desirable to clamp bearing rings whenever feasible. This assures positive bearing location and retention, axial and radial rigidity, and also a means of pre-loading the bearing. If these factors are not important, satisfactory performance is usually possible with snap rings.

However, if a clamping nut or cover plate is replaced with some simpler device, several precautions should be kept in mind. First, if the outer ring rotates, a press fit in the housing is usually required; a snap ring or other nonclamping device may permit excessive creep. If heavy loads are involved, both a press fit and clamping device are often necessary.

The same principle applies to a rotating shaft. Again, shaft clamping is a second choice to a shaft press fit in preventing scoring and fretting corrosion.

Axial clamping of a loose-fit inner ring by a nut will be satisfactory if the clamping force is at least ten times the radial bearing load.

This leaves mountings for stationary shafts or stationary housings as the two remaining possibilities for snap rings or other nonclamping locaters. But even under these circumstances a heavy load or vibration often makes it desirable to use positive clamping. Speed is another factor and considerable liberties can be taken when low speeds are involved.

What can be done to eliminate selective assembly to obtain minimum looseness between bearing OD and housing bore, and bearing ID and shaft?

Any step to eliminate selective assembly must introduce closer tolerances not only for the shaft and housing, but also for the bearing ID and OD. With respect to bearings, this can be accomplished by specifying a higher ABEC grade–which, of course, also increase costs.

To reduce tolerances on housing bores, such processes as *borizing*, which is a light, single point carbide tool operation; *bearingizing*, which is a peening tool operation, and *ballizing*, which is a ball broaching operation, have been used with considerable success.

With regard to shaft sizing, careful grinding is generally satisfactory, although *bearingizing* is sometimes used.

What can be done to permit a wide speed range without sacrificing mounting rigidity?

Because low speeds are generally associated with heavy loads and high speeds often imply light loads, rigidity requirements for the two ends of a wide speed range are not compatible. A satisfactory compromise usually can be achieved by providing a relatively heavy bearing preload for low deflection under large loads, and, at the same time, furnishing a lubrication and cooling system to dissipate excessive heat developed at higher speed. In doing this, some sacrifice may be necessary both in rigidity at low speed and bearing life at high speed.

What are the advantages and disadvantages of bearings having a face keyway in the inner and outer race, which could be positively locked to avoid race creep during service?

In most instances, it is not necessary to resort to such locking procedures to prevent rotation of the race, particularly where an interference fit is used. High points of eccentricity marked on precision bearings are located so that bearing can be mounted to oppose and nullify any ec-

centricity of the shaft. When duplex bearings are used, high points of eccentricity are lined up to prevent "fighting eccentricities."

What are the advantages and disadvantages of ball bearings with lighter ring sections and a larger number of smaller balls?

Advantages: (1) shaft size is larger for same housing diameter; (2) bearings are narrower in width than the extra light series; (3) they are readily adaptable for hollow spindles carrying light loads; (4) at high speeds, severe ball loads from centrifugal force are often avoided; and (5) there is a substantial weight saving, especially in the larger sizes.

Disadvantages: (1) bearing rings are difficult to manufacture requiring special chucking and quenching fixtures; (2) they are generally expensive; (3) bearing capacity and fatigue life is lower; and (4) bearings are more sensitive to shaft and housing irregularities.

What are the bearing requirements for high speed precision spindles?

High precision bearings equivalent to ABEC 7 or better must be specified where extreme accuracy is required. At the same time, the shaft and housing tolerances must equal those of the bearings, and bearing fit, squareness of shoulders, and alignment of the housing bores are critical.

For maximum life, provision must be made for adequate lubrication and, in high speed units, for cooling, such as is provided by an air-oil-mist system.

To obtain the ultimate in accuracy, axial preloading of the bearings is recommended. This not only will reduce deflections, but also assure correct seating of the balls in the raceways.

What conditions dictate using grease or oil as a lubricant?

Oil is always a more effective lubricant than grease. All of the research on grease has been directed toward providing lubrication comparable to that obtained with oil systems.

Grease lubrication, however, can promote the following advantages: (1) supply a reservoir of lubricant that will stay in place without elaborate closures; (2) provide lubrication for extended periods of time without renewal—from a few weeks to several years depending upon the operating temperature; (3) under some conditions, the degree of dirt contamination is reduced and, therefore, bearing life improved because the infrequent lubrication provides fewer opportunities for dirt to enter the bearing; (4) provide adequate lubrication at speeds up to approximately 3,500 fpm with steel separators, up to 5,000 fpm with nonmetallic separators; (5) greases are available, which are capable of operating at temperatures of −100 to +350 F; and (6) grease lubricated bearings with simple seals can often be as effective in sealing out external dirt as oil lubricated bearings with elaborate seals.

Some of the limitations of grease are: (1) with currently available compounds, speed is limited to the values given above; (2) grease has little, if any, effect in carrying away heat; and (3) deteriorated lubricants cannot be removed and replaced with fresh material as conveniently as in an oil lubrication system.

What is the limiting speed of grease sealed ball bearings?

Three factors determine the limiting speed of the bearing: (1) limiting speed of separator; (2) limiting speed of seal; and (3) load.

With frictionless seals, metallic separators, and light loads 3,500 ft/min of the inner ball race in a good average value. For nonmetallic separators this can be increased to 5,000 ft/min. These represent 11,000 and 16,000 rpm, respectively for a 1.0 in. bore bearing. For felt and synthetic rubber rubber-type seals, 2,500 ft/min (7,100 rpm) is generally accepted as the maximum speed that can be attained without excessive temperature rise.

As the ratio of capacity to load approaches 3.0, these values must be reduced approximately 15 per cent. As this ratio approaches unity, limiting speed must be further reduced.

What are the advantages and disadvantages of air-oil-mist lubrication?

This is the best means of lubricating high speed ball bearings since it not only lubricates, but also cools the assembly. The advantages are that the mist can be carried some distance without condensing in the lines so one lubricator can serve a number of positions on a machine, and that the flow of air out of the bearing will help to keep out contaminants.

The main disadvantage is the requirement for clean compressed air. Another objection might result from the amount of oil-fog exhausted into the room, when a large number of units are involved.

With unsealed bearings, what lubricant should be used if it must also lubricate gears, journal bearings, and needle bearings?

The requirements of the gears are usually the controlling factor, and the only problem lies in controlling the quantity of lubricant that reaches the ball bearing. The same applies to needle bearings. With journal bearings, their design must consider the viscosity of the gear oil.

Can the same lubricant be used for all of the bearings in a company's machines?

Within the speed limitations previously given, and assuming that extremes of temperature are not involved, it is probable that all grease-lubricated bearings could be satisfied with a single product. Also, if wide variations in operating temperatures do not exist, it should be possible to select an oil viscosity that would allow satisfactory oil lubrication. However, if the question is whether one specific lubricant could be expected to be suitable for all the lubrication points on a machine tool, including spindles, slides and ways, feed mechanisms, gears, etc., the answer is undoubtedly "no," since the chemical and physical requirements of the lubricant differ widely for these various applications.

Is oil jet spray into the bearings preferred to the low-oil-level dipping method?

The oil-jet spray is desirable since it assures a continuous supply of fresh lubricant to the bearings. It is also possible to incorporate a filter into the oil-jet system which will remove contaminants and thereby reduce the possibility of bearing damage from dirt.

The main advantage of oil-jet lubrication is in reducing operating temperatures in heavily-loaded, high speed bearings.

With the oil-level method, the bearings run partly submerged. If loads and speeds are such that considerable heat is developed, the bearings could become overheated unless a circulating system is employed.

When and why use plastic seals with grease lubricated angular contact bearings?

Thin washers of a plastic such as Synthane have been used with considerable success on slow speed machine tool applications. These washers are usually inserted between the bearing and housing shoulder so that a portion of the washer face comes in rubbing contact with the inner ring bearing face. As a result of this mounting method, the seal resists pressures and contaminants from the outer side of the bearing but not from the inner side. Accordingly, such seals are commonly used when bearing housings are exposed to liquids such as cutting compounds. By the same token, they are not particularly suitable for keeping a fluid lubricant within the bearing, especially if the bearing is subjected to periodic internal pressure, as from breathing.

What are the advantages and disadvantages of shaft rubbing seals, face rubbing seals, and labyrinth seals?

Some of the factors that determine the proper selection of a closure are: (1) requirements differ for a horizontally and a vertically mounted shaft; (2) maximum recommended surface speed of the spindle in ft per min at the point of closure contact must never be exceeded or high temperatures will result; (3) neoprene closures have been successfully used at speeds up to 3,000 fpm and maximum temperatures of 300 F, but at this speed an extremely flexible sealing lip is required to reduce pressure and thereby minimize temperature and lip wear; (4) sealing efficiency and operating temperature are almost in direct proportion to the finish of the shaft surface contacting the sealing member. A finish of 5 micro in. for high speeds and 20 micro in. maximum at lower speeds is recommended. A hardness of Rockwell C 30 to C 40 is desirable; a soft shaft having tool marks must never be used; (5) excessive runout or whip of a shaft decreases seal efficiency. Precision spindles are usually held to within 0.0001 to 0.000 2 in. TIR depending on size, and, therefore, present no serious runout problem as far as seal efficiency is concerned. On larger diameter, slower rotating shafts in non-precision positions, larger runouts are allowable; (6) to assure satisfactory seal performance, comparatively close tolerances of shaft OD and housing bore diameters are essential. For shaft diameters up to 3 in., a tolerance of ± 0.003 in. is satisfactory. For shafts 3 to 10 in., tolerances of ± 0.005 -0.010 in. are permissible. Housing bore diameters should be held to ± 0.001 up to 3 in. and ± 0.0015 from 3 to 6 in., never exceeding ± 0.002 in. for diameters larger than 6 in.; (7) in mounting, care should be taken to have the sealing lip facing in the recommended direction. (Scoring of a spindle may result at high speeds when no lubricant can find its way to the contact surface between the lip and shaft); and (8) face rubbing seals are used for high speeds, and when pressures are unbalanced. (Although pressure increases friction, sealing is more efficient. Light spring pressure holds the narrow lapped seal surface in contact with either the face of the bearing inner ring or an accurately fabricated collar. For nonpressure applications, the sealing member can be plastic, carbon or metal; the mating member can be hardened lapped steel).

If surface speeds are too high to permit the use of contact seals, the labyrint type can be used.

Where the radial face of a slinger rotates close to the stationary face of a housing a centrifugal pumping action is set up. The resulting outward air flow carries away heat and in the case of wick-fed oil lubrication, draws the oil outwardly through the bearings. The centrifugal action of the slinger deflects coolant and abrasive preventing its entry into the housing and bearings.

Where grease lubrication is used, the housing and slinger design must be such that the slinger cannot pump the grease out from the bearing. In the case of air-oil-mist lubrication where the system operates under a definite air pressure, the slinger action is less important.

Start Looking for Engineers

In a recent report from the Stevens Institute of Technology, figures show that the competition between industrial firms to hire this year's crop of engineers is stronger than ever. So far over 170 companies have scheduled visits to the Stevens campus this spring to interview the 128 members of the 1955 graduating class. In addition to the many large firms, a number of small and medium sized companies are seeking the services of these engineers.

Starting salaries offered are averaging more than $370 per month this year as compared to the average $360 last year. In some cases offers have run as high as $440.

Figures show that the 128 students will take part in about 2000 interviews with representatives of prospective employers, averaging more than 15 interviews per student. Even those due to enter military service will be signed up. By accepting a position before entering the Army, the engineers will gain longevity benefits during their hitch in the service. Some students will get more than ten job offers, indicating that many prospective employers will be unsuccessful.

FINANCIAL AID TO HIGHER EDUCATION

Our Colleges and Universities Are Living on Borrowed Time

. . . time borrowed from underpaid faculty members

The chart on this page tells a story of profound importance to every American. It is the story of the financial beating our college and university faculty members have been taking in the past 14 war and postwar years.

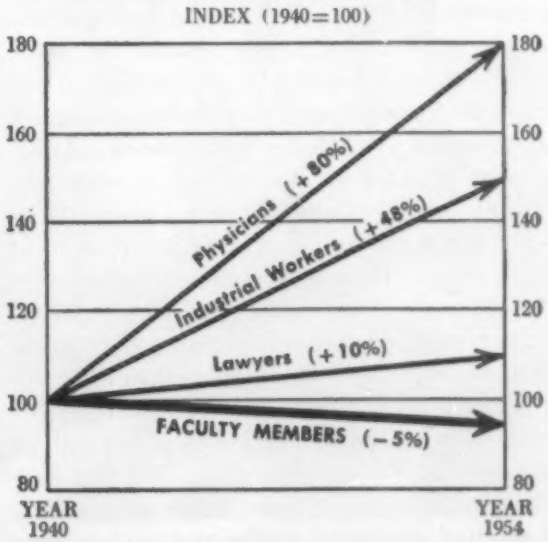
On the whole, this span of 14 years has been one of great and growing prosperity. But, as the chart shows, our college and university faculty members have, as a group, had less than no share in it.

During this period, from 1940 through 1954, the real income of the average industrial worker (that is, what his wages would purchase in goods and services) has increased by almost one-half. Among professional groups, physicians have enjoyed an increase of about 80 per cent in their real income. Lawyers, far less favored financially, have had an increase of about 10 per cent. But faculty members have not only had no increase at all; over these years of prosperity their average real income has fallen by 5 per cent. These figures do not take account of the increase in taxes since 1940.

Senior Teachers Hardest Hit

These figures are, of course, averages. For some groups of faculty members it has been better; for others worse. It has been particularly hard on senior faculty members. Between 1941 and 1953 their salaries lost about 8 per cent of their purchasing power. Being deeply committed to their careers they could not respond to alternative employment opportunities as readily as could their junior colleagues. For junior faculty members there was some increase in real income between 1941 and 1953 but only about half as much as the average for the nation.

What's Happened to College Faculty Salaries*



* Real Income before Taxes

Source: Council for Financial Aid to Education; U. S. Dep't of Commerce; U. S. Dep't of Labor.

Public Colleges Fare Better

There are also marked differences in the average financial reward received by faculty members in different types of colleges and universities. A recent study by the Council for Financial Aid to Education indicates that, in the last academic year, 1953-1954, teachers in privately endowed, independent colleges and universities were paid an average salary about $1000 less than that paid to faculty members in tax-supported institutions. The same study indicates that salaries far below the average are especially common for faculty members in the small private liberal arts colleges. This study found that during the last academic year the average salary of all college and university faculty members was about $4700.

The special difficulties under which the independent colleges and universities, and particularly the independent liberal arts colleges, are laboring to get back on their feet financially have been discussed in previous editorials in this series. These difficulties underline the need of special help for these institutions to which business firms are now contributing in increasing volume. However, the problem of providing better salaries is not peculiar to any particular type of institution.

Faculty Members Not Greedy

It is not easy to prescribe a precise standard of fair pay for college and university faculty members. This is partly because they put less weight relatively on money rewards than they put on rewards of scholarly accomplishment and prestige. Consequently, they have consistently been willing to work for very modest salaries in relation to the intellectual ability, education and application required. Obviously, however, it is the dictate both of fairness and good judgment to see that faculty members are given a roughly proportionate share in the general prosperity. Indeed, their crucial role in our society could be made to justify a larger share than this.

There is no way to know with any degree of precision what the underpayment of our college and university faculty members over the past 14 years has actually cost the nation in terms of reduced quality of intellectual performance of those institutions. One reason is that the damage has been minimized by the devoted services of many faculty members who have loyally stuck to their jobs in spite of the great financial discouragement.

It is obvious, however, that, if no grave deterioration in the intellectual performance of our colleges and universities has occurred so far, it is because we have been living on borrowed time. It is time borrowed from faculty members who have, in effect, been subsidizing these institutions by their financial sacrifice. This arrangement is not only a menace to the cultural and intellectual life of the nation, it is also a menace to our national security in a time when successful national survival may well depend in peculiar degree on the full development and utilization of our intellectual resources. We depend on our college and university faculties pre-eminently to provide this development. Adequate financial reward for such service is an elementary form of national insurance.

Many of our colleges and universities are working hard to improve the financial lot of their faculty members. Business firms are also playing an increasing role of providing the necessary financial assistance. The methods being used by business for this purpose will be the subject of another editorial in this series. However, **vastly more must be done, and quickly, to stop the financial beating being taken by our college and university faculty members if the nation's welfare and safety are to be properly protected.**

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nationwide developments that are of particular concern to the business and professional community served by our industrial and technical publications.

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Donald C. McGraw

PRESIDENT

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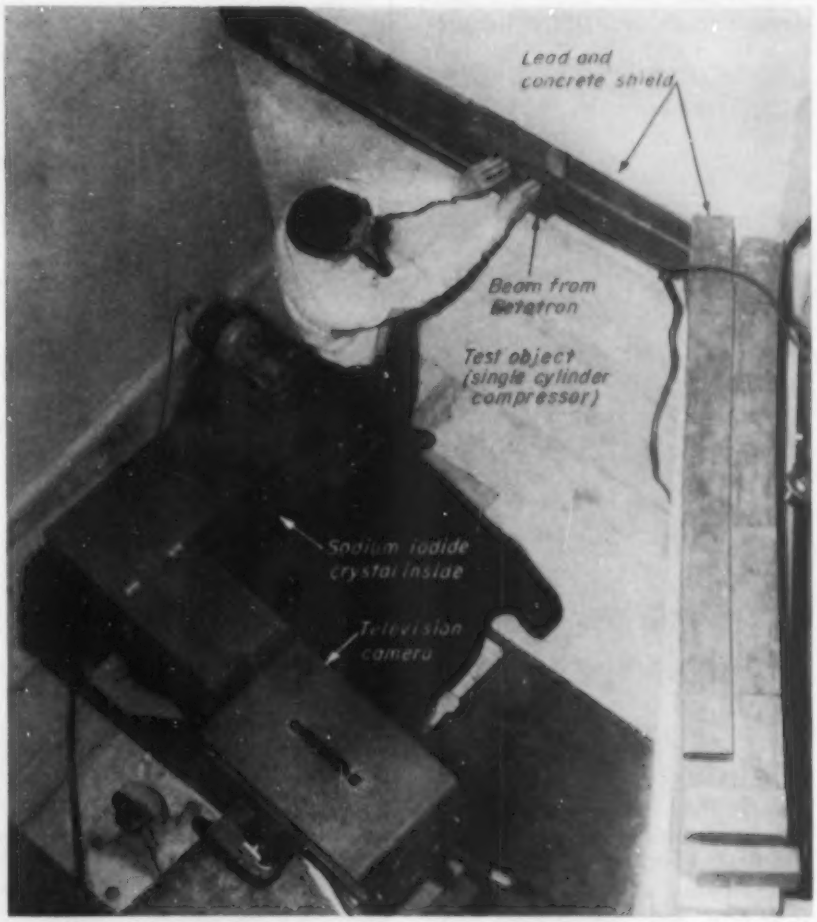
TECHNICAL NEWS

Looking Inside An Engine In Operation

At the recent National Bureau of Standard's Open House–its first in 17 years–leaders in the fields of science, industry, education, and government were shown samples of the variety of work in which the Bureau is engaged. What started out as a late addition to the show, and which later turned out to be the main attraction, was the continuous display on a television screen of an x-ray image of a piston inside a compressor cylinder while the machine was in operation. High-energy x-rays from a 50-million volt Betatron were used, and the image was picked up by a television camera and transmitted via a closed circuit to a 21-in. televsion screen in the High Voltage Lab., where the Open House show was held.

Detecting flaws in large castings or assembled mechanisms is of great importance to industry, and low-energy x-ray radiography has been used for years to inspect metallic parts. However, these low energy x-rays are absorbed by most materials, which limits the thickness of the material that can be penetrated. Also, there is much scattering produced in the material being examined, and the large size of the x-ray tube focal spot has limited the detail that can be seen. These limitations are much less severe for the high energy x-rays of a Betatron and Synchrotron, and much thicker specimens may be examined.

As part of this program at NBS, an instrument called a "pattern amplifier" has been developed. This device acts as an x-ray image intensifier, by continuously detecting, amplifying, and displaying low-intensity x-ray images which are transmitted by large objects. The major component of this amplifier is a large cylindrical, thallium-activated sodium iodide crystal,

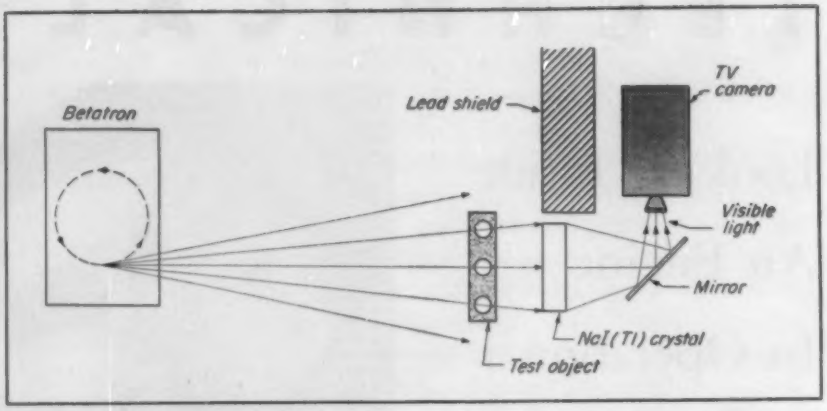


SCIENTIST AT NBS adjusts slot in lead and concrete wall through which the high energy betatron x-rays pass. Ordinary camera may be substituted for television camera here to photograph the image for permanent records.

MONITOR SCREEN picks up image of piston, wrist pin, connecting rod, crank pin and web as the small compressor shown above is put into operation. It points to the day when any automobile or airplane engine can be x-rayed while in operation.

which converts the x-ray images into optical images. When bombarded with an x-ray beam which has passed through an object with internal structure, the crystal gives off visible light. If the crystal is oriented with its flat surfaces perpendicular to the x-ray beam, a visible x-ray image may be seen. Some of these crystal "converters" have diameters up to 7⅜ in. and thicknesses up to one inch.

The pattern amplifier is sensitive enough to detect x-ray images with an intensity as low as 2×10^{-5} milliwatts/cm² at the crystal. Thus, using the 180 Mev Synchrotron instead of the 50 Mev Betatron, it is possible to display x-ray images through as much as 18 in. of steel or 7½ ft. of concrete.



A SCHEMATIC DIAGRAM of the x-ray pattern amplifier, showing the x-rays emerging from the Betatron, passing through the test object, and projecting a shadow picture which is converted into visible light by the thallium activated, sodium iodide crystal. The television camera transmits this picture to a observation point where it can be viewed on a monitor.

Flexible Tube Channels TV and Telephone Conversations

The ordinary looking hose-like tube shown at right is, in reality, Bell Telephone's new long distance waveguide, a radically different means for transmitting television and telephone conversations. Quite different from present day cable or radio relay systems, the flexible copper tube about 2 in. in dia. channels radio waves any way it is bent, and may someday simultaneously carry tens of thousands of cross-country telephone conversations along with hundreds of television programs. Top capacity for today's coaxial cable systems is 1,860 two-way telephone conversations and two TV programs simultaneously on a pair of coaxial tubes.

Waveguides made of solid metal tubing, something like a water pipe, have been used for some time for short distances. However, the tubes must be perfectly straight.

The new long distance waveguide is also a hollow tube, but is made of a thin copper wire, very tightly coiled, and wrapped inside a flexible outer coating which holds the coiled wire in place. This type does not have to be straight, and can actually carry signals around corners.

The system operates in a frequency range so high that it has never been put to practical use for communications. In fact, there is no name for the range, although the short waves used are known as millimeter waves. The "super high" frequency range established by the FCC goes up to 30,000 megacycles. The carrier frequency for the new waveguide is about 50,000 megacycles.

The major difference between transmission through the new waveguide and through previous systems is that the higher the frequency in the waveguide, the less the loss through attenuation. This is the reverse of other forms of transmission. Bell is also studying the use of 1 mm wave lengths.

Flat TV Tube Makes Flying Easier

Everybody seems to be looking for the ideal flat television tube, and Willys Motors, Inc. is no exception. Their West Coast Electronics Division just announced its version, which in addition to giving the television industry a new look, also shows promise of simplifying aircraft instrumentation. At right is a mockup by Douglas Aircraft showing how this flat tube can be adapted to the airplane cockpit of the future. Below is a schematic view of the flat, 3 in. thick, picture display tube.

The new tube consists of a phosphor screen sandwiched between two glass plates. This area is then evacuated. The electron beam is injected in along the horizontal edge of tube, and flows in a field-free region along this edge, and adjacent to a row of *vertical* deflection plates. By the control of the voltages on these deflection plates, the beam can be bent vertically at any place along the edge of the tube. The beam then flows vertically in a second field-free region between a series of *horizontal* deflection plates and the electrically charged phosphor screen. Again, by controlling the voltages on the horizontal deflection plates, the beam can be deflected into the screen at any desired vertical level.

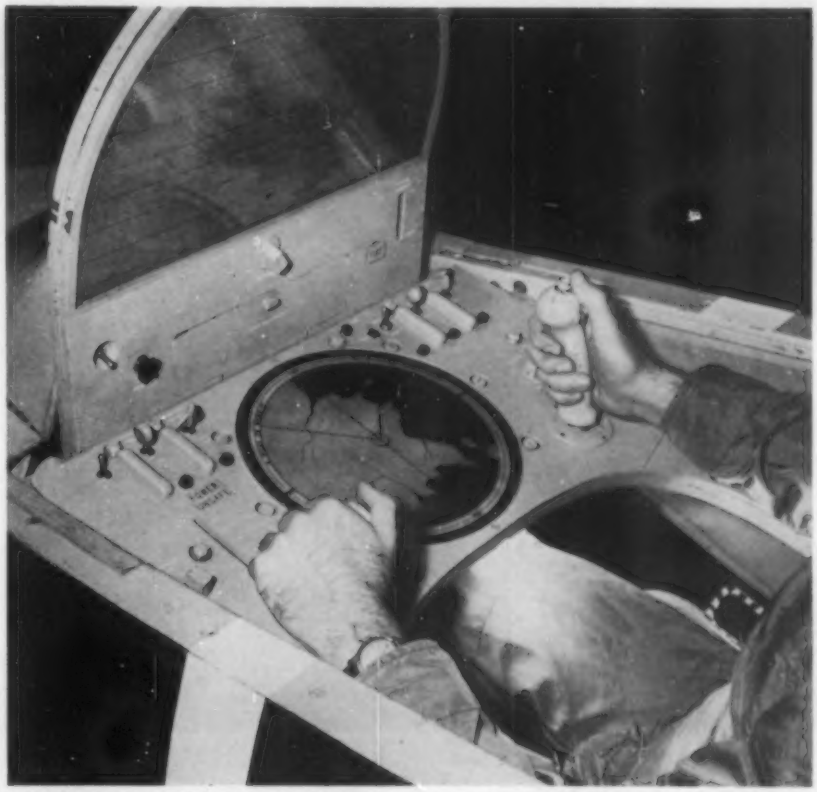
The tube is controlled by sequentially charging the voltage on the horizontal or vertical deflection plates—that is, all the plates are kept at a high voltage except those plates opposite the position at which it is desired to bend the beam.

One of the advantages of this deflection system is that it has a very powerful focusing ability. The convergence angle is large, and the beam blow-up, which occurs in other TV picture tubes, is not a problem in this tube. The powerful focusing also results in high definition and brightness.

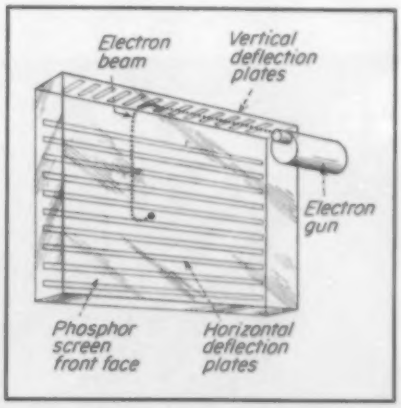
Aircraft Application—The new instrument panel, as envisioned by the Navy, would consist of two basic instruments—both television picture tubes. However, the TV tubes *would not* be used to present an actual picture of what is happening in the vicinity of the plane. One would be a transparent, semi-circular plate mounted vertically in front of the pilot where altitude, speed, and position of the plane would be shown. Physical features, such as mountains would be depicted artificially.

The second instrument would consist of a round plate mounted below the first. With physical features of the earth depicted by analogy, the appearance would be similar to a radar map. Information for navigation or traffic control would also be shown here. By calibrations around the rim, the number of miles to the pilot's base, fuel remaining, and similar information would be shown for quick and easy assimilation.

Another aim of the Navy's program is to reduce the control system to two basic controls: a control stick and a throttle. Six switches would be used to select specific types of information needed for take-off, landing, traffic control, and other specific situations.



A DOUGLAS AIRCRAFT MOCKUP of what the cockpit of the future plane (about 1958) might look like, incorporating the new instrument and control systems. The navy plans to find the proper way of presenting information, and to devise foolproof equipment and increase flight safety. An estimated 75 per cent reduction in instrument training time could result from this program.



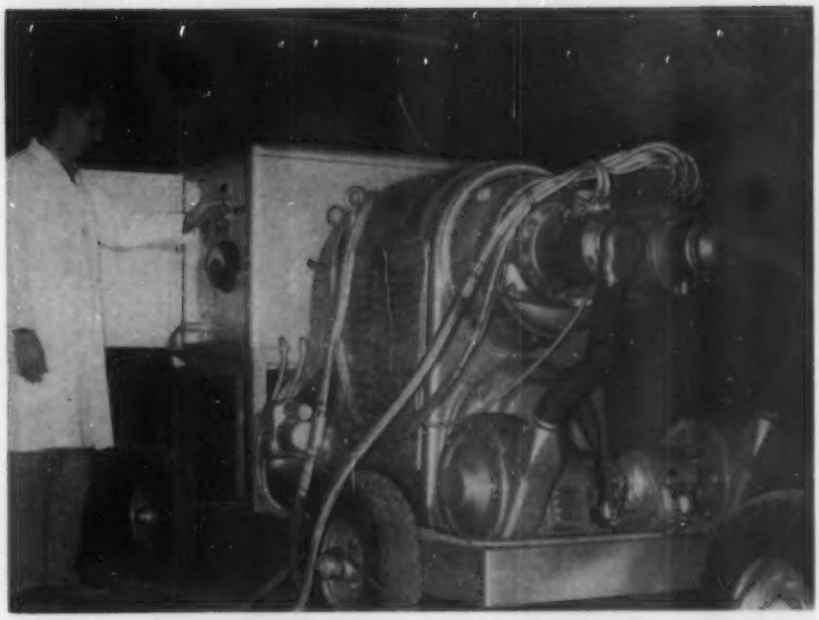
WILLYS ELECTRONICS' NEW 3 IN. FLAT TELEVISION TUBE has electron gun mounted on the side instead of rear. First screen was 15 in., but larger models have already been built. Using the same principle, it has been said that a color TV tube would be easier to make. Compact and portable, the tube uses only electrostatic principles, eliminating conventional heavy, magnetic components.

THE NEWS IN PICTURES

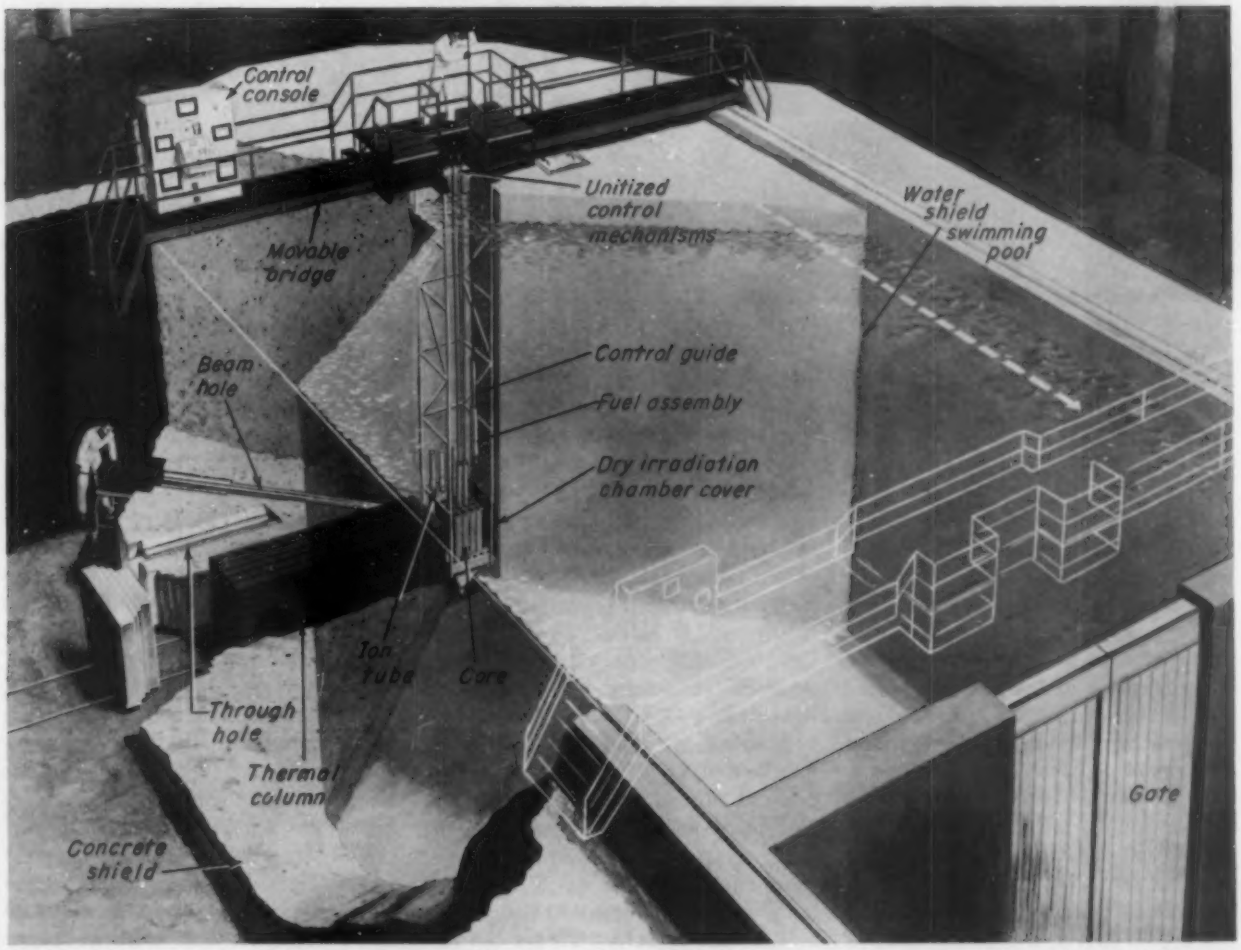
SCALE MODELS of storage tanks are set up before receiving a simulated bomb blast in a 6 ft. dia., 150 ft. long shock tube designed by the Armour Research Foundation of Illinois Institute of Technology. To get different shock wave pressures and durations, the tube has interchangeable sections of varying lengths. The foundation of the tube is of reinforced concrete to help absorb the maximum recoil force of 600,000 pounds. In operation, a certain amount of combustible gas is introduced into one section of the tube and is confined by a light diaphragm. When the gas is ignited, shattering the diaphragm, the released pressure wave travels down the tube to the test section where a building model is placed. The resulting forces are recorded.

ONE OF 24 HUGE MUFFLERS for three wind tunnels being fabricated by the Consolidated Western Steel Div. of U. S. Steel for the U. S. Air Force, Arnold Engineering Development Center, Tullahoma, Tennessee. The tunnels will be used for testing aircraft, missiles, and missile engines at supersonic and hypersonic air speeds. Mufflers like the 15 ft. dia. one shown here are conical pressure vessels with honeycombed internals. The internals are arranged in either pieshaped or vertical vane patterns. The vanes consist of 13 panels with millions of 3/16 in. holes.

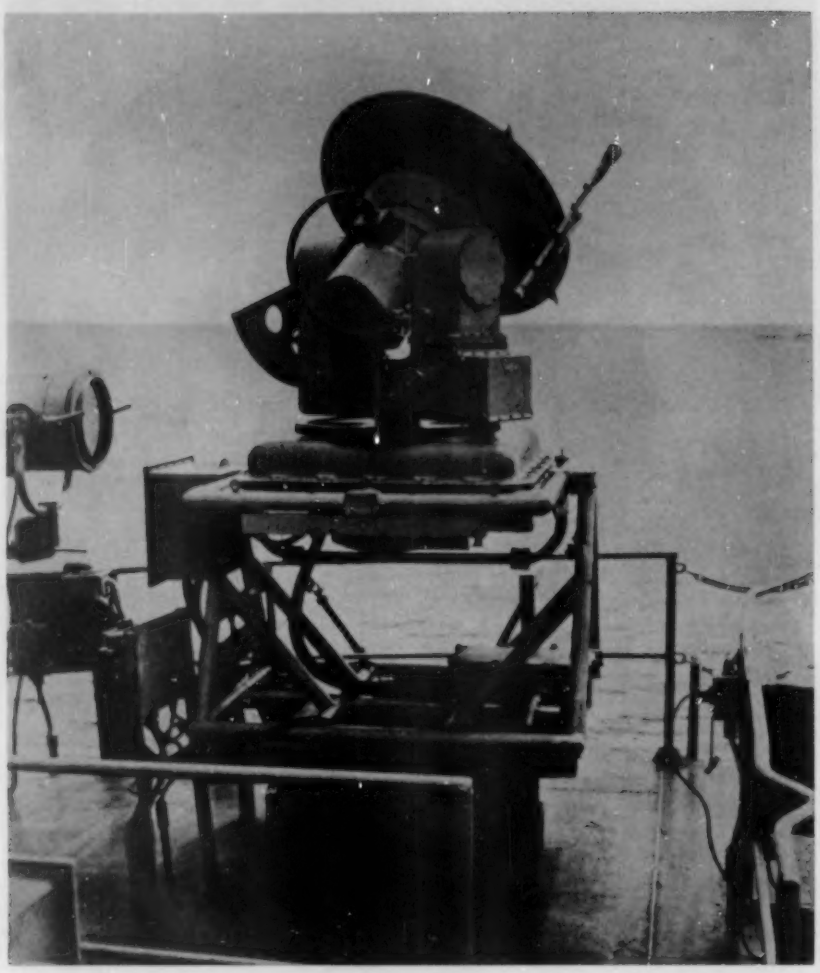
TECHNICIANS OF THE SIGNAL CORPS are assembling the terminal units of a new portable, twelve-channel telephone system designed for field service by Bell Telephone Laboratories. These stackable units are part of a system which can carry twelve conversations simultaneously up to distances of two hundred miles. Another 4-channel system can be used for four simultaneously at distances up to 100 miles. Several of these systems linked together can form a communication system of 1,000 miles. Indicating the use of miniaturized parts, the new 4-channel units weighs 178 lb. and occupies 5.5 cu. ft. of space, as compared to 475 lb. and 20 cu. ft. of the old unit.



BOTH JET ENGINES of the Scorpion F-89D all-weather interceptor are simulated by this special unit composed of two 50-hp variable speed drives. Developed by Northrop Aircraft and called "Silent Sam," this unique electro-mechanical inspection device reduces engine run-up time by 75 per cent by checking electrical hookups before the engines are installed in the plane. It takes only 40 minutes to make all electrical connections, and five minutes to check all circuitry to and from the engines. Tachometer indicators and other controls are mounted on two portable units beside the cockpit where they can be regulated by one man.



A CUTAWAY DIAGRAM showing the first nuclear research reactor to be owned and cooperatively operated by private industrial concerns. Designed by the American Machine & Foundry Co., the reactor is of the "swimming pool" type, using a solid-fuel type with a core similar to that in the Materials Testing Reactor at the National Reactor Test Station in Idaho. Leading industrial concerns will be represented on a board of directors which will establish the operating policy for the reactor facility. Participating companies will be from the electronics, petroleum, food pharmaceutical, chemical, ceramics, rubber, metals, textiles, agricultural, machinery, and other industries. Cost of the reactor and facilities is estimated at between $1 and $1.5 million.



Radio Sextant Operates In All Weather

Work for the navigation officer aboard naval ships will be nil as a result of a radio sextant which automatically tracks the sun through rain, snow, and clouds. Built by the Collins Radio Co. of Cedar Rapids, Iowa, the sextant has been undergoing tests for the past year. Results of these tests showed that it had an accuracy in the elevation angle of the sun comparable to that obtained with a hand-held sextant, and with better stabilization and the correct location aboard ship, the accuracy can be further improved. All of the sextant's calculations can be recorded automatically.

Equipped with a 30 in. diameter parabolic reflector, and using a sensitive radio receiver, the sextant detects microwaves emitted from the sun. The receiver operates a servo system which moves the reflector to track the sun and measure its position. From this information the navigator can locate the ship's exact latitude and longitude.

The thermal radiation of the sun, in the form of noise, is of a low level, and was not detectable until radar led to the development of a receiver and antenna techniques for the low centimeter wave length region. From this it was possible to develop an antenna and receiver at a wave length of 1.25 cm., which could detect radiation from the sun in a 15 megacycle bandwidth.

A wave length of 1.9 cm was picked for the first model of the sextant, because at this wave length atmospheric absorption during all weather conditions was low. In addition, it was short enough to get an effective antenna power gain of 6,000 times from a 30-in. dia. reflector. To get the signal modulation needed for automatic tracking, the narrow antenna beam in a circle (about one degree wide) was scanned. So, when the axis of the scan was directed toward the center of the sun, constant energy would be received.

Besides the shipboard sextant, an airborne sextant has been developed, and is now being tested. Also, an experimental sextant operating at a wave length of 0.87 cm. is being tested to get accuracy information and atmospheric absorpion and refraction magnitudes. Tests show that the 0.87 cm. radio sextant can give the altitude and bearing angles of the sun with a probable error of one minute of arc except during severe rain storms.

Westinghouse Opens New Turbine Laboratory

Electric power consumption is increasing at a rate of 7.4 per cent per year, or 104 per cent in the next ten years, according to J. R. Carlson, engineer manager of Westinghouse Electric's new Steam Division Lab. in South Philadelphia. The trend of future generating equipment is toward increased capacity, with increased efficiency coming from still higher pressures and temperatures. Turbines now in the design stage call for steam at 5,000 psi and 1,150 F, bringing new problems in high temperature materials. The economic pressure behind these advances is that a one per cent deduction in heat rate justifies an additional expenditure of $175,000 in an efficient 200,000 kw utility steam plant.

By 1963 atomic energy is expected to supply steam for about 1 per cent of the electric generating capacity. The gas turbine too, will supply a major part of the capacity in units with ratings between 1,000 and 15,000 kw.

The new laboratory is equipped to conduct long-range development as well as product design functions, on full scale models and component parts, and also has facilities for the design and manufacture of its own test equipment. Products include steam turbines, gas turbines, axial-flow compressors, and heat exchangers. Units up to 15,000 kw can be tested. Laboratories are equipped for aerodynamics, combustion and heat exchange tests, and for mechanical tests such as vibration, lubrication, and control systems.

Investigation of the use of nonwetting agents to promote "drop wise"

rather than film condensation promises to reduce the size of steam condensers. Aluminum and titanium are under study as condenser tube materials. Elasticity of the film of lubricating oil in main bearings is being studied for its influence on rotor vibration. In developing turbines for low-grade fuels, corrosion from ash has been greatly reduced by the use of "additives" in the fuel which increase the melting temperature of the ash.

A new nickel-chromium brazing alloy offers promise for high temperature service; blade materials with higher damping capacity are being tested; some recent cermets exhibit ductility approaching some of the superalloys.

Defense Suppliers List Cut

From Washington comes news that there will be a cut in the list of defense suppliers, known as the "Register of Planned Wartime Material Suppliers." This is the master record of the 34,000 plants lined up to produce top-priority military goods under full mobilization. Estimates are that about 10,000 firms will be crossed off.

Those firms going off the list include some deadwood—merged companies, companies out of business, and those with changed product lines—also, many producers who have not kept in touch with mobilization officials.

For those companies who want to stay on the list, they should see the armed service planning officer who is responsible for their plant's role in mobilization, and renew production schedules. To get on the list, inform the services of your plant facilities.

Reinforced Plastics In Industry

Increasing industrial uses for reinforced plastics were evident in exhibits, papers and discussions at the 10th Annual Conference of the Reinforced Plastics Div. of the Society of the Plastics Industry, which was held in Los Angeles in February. While there was much emphasis on military and aircraft parts, much of the information on properties and fabricating methods were of general interest, including discussions on plastic tools.

Coming Events

APR. 25-26

Automatic Control Conference sponsored by the ASME's Instruments and Regulators Division, Univ. of Michigan, Ann Arbor, Michigan. Conference chairman is Dr. John Hrones of the Mass. Institute of Technology in cooperation with the Detroit section of ASME and the engineering faculty of Michigan University. Papers will be based on the control of physical systems, physical systems with a human operator, and business and economic systems. Emphasis will be on the basic dynamics of control rather than on the mathematical methods of solution.

APR. 27-29

Society for Experimental Stress Analysis, Hotel Statler, Los Angeles, Cal. More information on this meeting may be obtained from Dr. W. M. Murray, Sec-Treasurer, P. O. Box 168, Central Square Station, Cambridge 39, Mass.

MAY 10-12

National Show and 11th Annual Meeting of the Metal Powder Association, Bellevue-Stratford Hotel, Philadelphia, Pa. Technical sessions at the meeting will be divided into: (1) a general session devoted to papers relating to a variety of aspects of powder metallurgy; and (2) an Electronic Core session consisting of a separate meeting on subjects in the electronics field. Some of the papers listed are: Finishing and Plating of Metal Powder Parts; Pre-Alloyed Steel Powders and Application; The Economic Production of Metal Powder Parts in Small Volume; A Powder Producer Looks at Titanium Powder Metallurgy; A Fabricator Looks at Titanium Powder Metallurgy; Applications of Ferrites to Memory Systems; Results of the Evaluation Program for Iron Powdered Cores; and others.

May 16-20

1955 National Materials Handling Exposition, International Amphitheatre, Chicago, Ill. More than 200 companies expected to participate. Theme of the show is: "The Concept of Obsolescence," emphasizing that most handling equipment put into use in recent years is already outmoded by great advances in the field.

June 2-3

1955 I.R.E. Materials Symposium, Convention Hall, Philadelphia, Pa. Jointly sponsored by the Philadelphia section of the Professional Group on Components. Keynote of the papers will be engineering materials for electrical and electronic applications.

JUNE 5-10

ASME Oil & Gas Power Conference, Hotel Statler, Washington, D. C.

JUNE 7-10

American Welding Society's National Spring Meeting, Hotel Muehlebach, Kansas City, Mo. To be held in conjunction with the annual Welding Show. Thirty-nine papers will be presented at the meeting, with discussions on: use of quenched and tempered steel for welded pressure vessels; use of iron powder coated electrodes; uses of carbon dioxide as a shielding gas in gas-shielded metal arc welding. Two sessions will be on Weldability and Research, and a third will cover the coordination of the society's standards and specifications. There will be sessions on welding for aircraft, and for machine and building structures.

JUNE 16-18

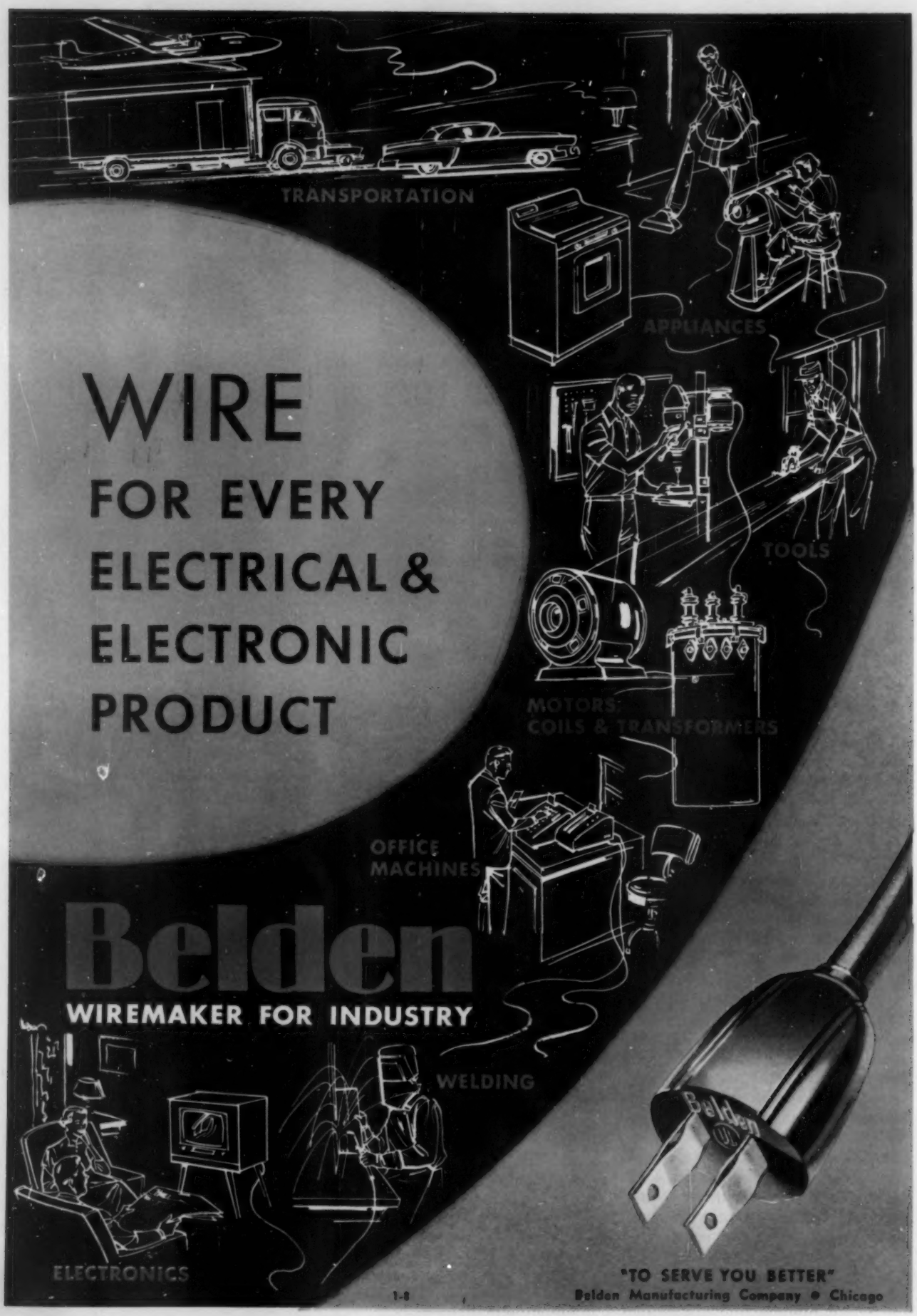
ASME Applied Mechanics Conference, at Rensselaer Polytechnic Institute, Troy, N. Y.

JUNE 19-23

Semi-Annual Meeting, American Society of Mechanical Engineers, Hotel Statler, Boston, Mass.

JUNE 20-23

American Electroplaters Society, 42nd Annual Convention, Cleveland, Ohio. The Industrial Finishing Exposition will be held concurrently in the Public Hall. Titles of some of the papers are: Plating Powdered Metallurgy Bronze Parts; High Speed Brass Plating; Surface Preparation; Fatigue of Plated Steel Parts; Finishing and Plating of Beryllium and Beryllium Alloy; Vacuum Metallizing; and others.


TRANSPORTATION
APPLIANCES
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FOR EVERY
ELECTRICAL &
ELECTRONIC
PRODUCT
TOOLS
MOTORS
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1-8

Increasing the Holding Power of Press-Fits . . .

. . . can replace more expensive methods of fastening. A combination of charts and formulas simplifies the analysis of press-fit variables.

RICHARD HAZELETT

Research Engineer, The Alpha Corporation, Greenwich, Conn.

THE USE of MoS_2 lubricants in press-fitted assemblies not only reduces scoring, galling and distortion, but also eases the assembly and disassembly of parts. This permits larger interferences between mating parts and allows the use of press fits to replace more expensive methods of fastening such as shrink and taper fits and keyways. For example, by using the maximum permissible bores in standard unhardened gears and a minimum interference of 0.001 in. per in. of dia, nearly all standard gears up to 6 in. pitch dia will sustain their maximum running load before the fit will slip.

The holding power, or resistance to slippage under running load, the induced tensile strength, and the expansion or contraction of the mating parts can be calculated quickly by using the combination of graphs and formulas given below. They are not restricted to any one lubricant.

SYMBOLS

a, b, c	= Diameters, in. (for a solid shaft, a = zero)
E	= Modulus of elasticity, lb/sq in., of part ab or bc
L	= Length of press fit, in.
N_{ab}, N_{bc}	= Dimensionless functions of a/b or b/c and Poisson's ratio. (Because of variations in Poisson's ratio, two curves appear in Fig. 1 based on a value of 0.28 for ferrous metals, and 0.33 for copper and aluminum alloys).
P	= Unit pressure within fit, psi. Does not apply near shouldered ends where local pressure will be higher.
Q	= Dimensionless function of b/c.
T	= Resistance torque available to prevent slippage.
U_{ab}, U_{bc}	= Dimensionless functions of a/b, and b/c.
Δb	= Interference, measured on the diameter, in.
μ	= Coefficient of friction within fit. For dry MoS_2 on press-fitted, hardened and ground steel parts, μ varies from 0.06 to 0.08. In determining the minimum available torque, a safer value of 0.05 is used.

EXAMPLE

Given: $b = 4.38$, $a/b = 9.14$, $b/c = 0.667$, $L = 3$, $\Delta_b = 0.002$ minimum, $\mu = 0.05$, parts ab and bc are steel.

Since both parts are steel, the graph lines marked "Fe" in Fig. 1 are used, and values of $N_{ab} = 11 \times 10^6$, $N_{bc} = 2.8 \times 10^6$, and $Q = 2.6 \times 10^6$ are obtained. Thus, from the formulas in Fig. 1

$$P = 10^6\left(\frac{0.002}{4.38}\right)\left[\frac{1}{\frac{11 \times 10^6}{29.5 \times 10^6} + \frac{2.8 \times 10^6}{29.5 \times 10^6}}\right] = 975 \text{ psi}$$

$$T = 1/2(975)(4.38)^2(3)(0.05)(\pi) = 4{,}400 \text{ in.-lb}$$

and

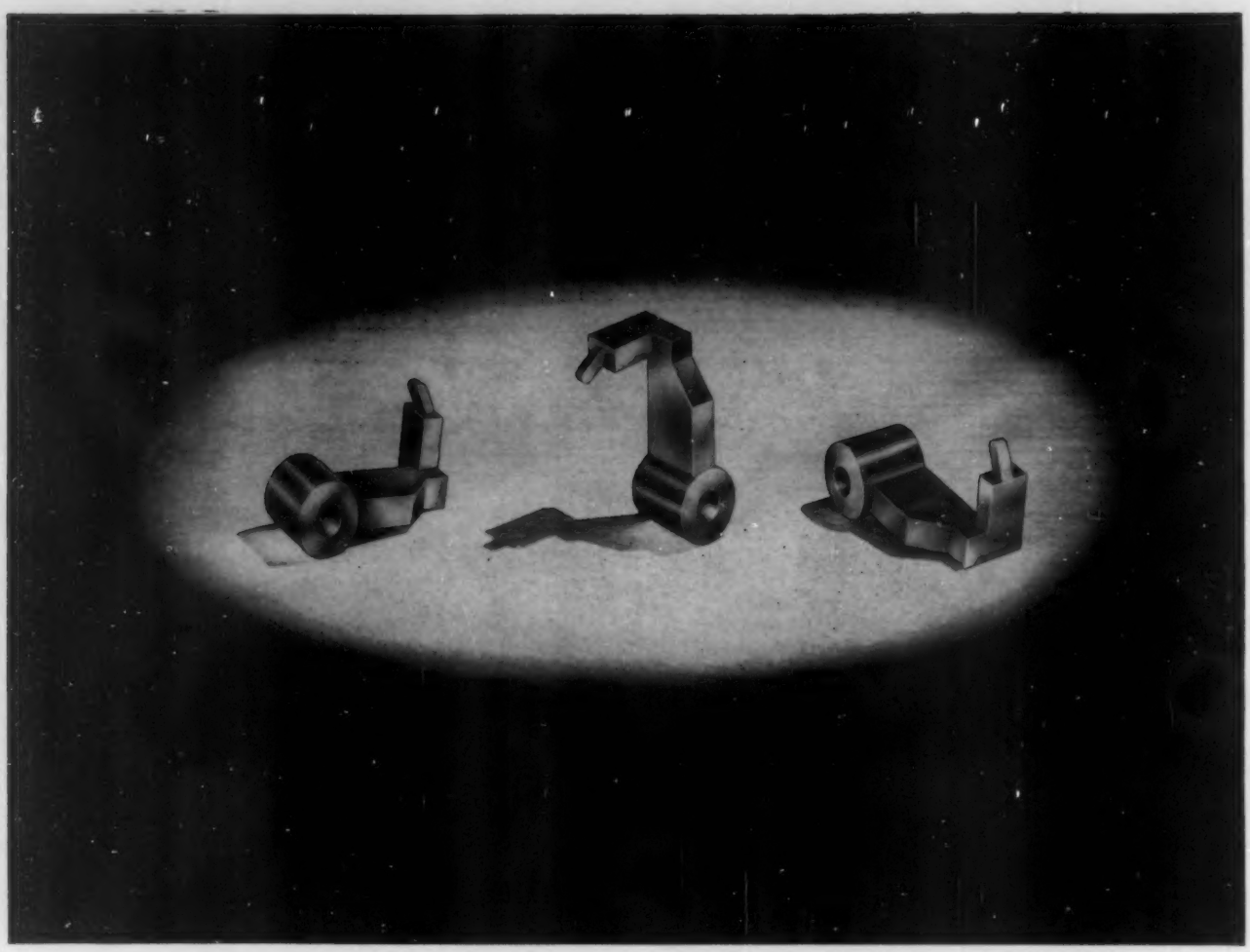
$$\text{Tensile stress} = (975)(2.6 \times 10^6)(10^{-6}) = 2{,}540 \text{ psi}$$

The graph in Fig. 2 is used to determine the elastic change in diameter.

What is Molybdenum Disulfide (MoS_2)?

Experts believe that the lubricating properties of MoS_2, which is a solid lubricant similar in appearance and feel to graphite, is the result of its laminar type crystal structure where each layer of molybdenum atoms is sandwiched between two layers of sulfur atoms Because of the strong affinity that sulfur has for metal, the layer of sulfur atoms

(continued on page 211)



Impossible in Powdered Metal? Not at PARKER

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This part—with projections in several planes, not to mention an I.D.-O.D. section—looked like an impossible job for powdered metal. Yet Parker made it in **one press operation**—complete—to close tolerances and tight "specs"—at relatively **low cost.**

This unusual piece points up the advantages offered by Parker powdered metal processing. Tough cost problems of conventional casting and machining methods often can be solved. Tensile strength, ductility and impact resistance can be closely controlled to meet rigid specifications. Powdered metal constituents can be precisely and uniformly blended for a wide range of requirements.

Parker's experience and facilities in producing a wide variety of powdered metal parts have saved money—and solved problems—for many users. Your problem may be one that Parker can solve in like manner. Just call the nearest Parker sales engineer listed at the left.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pa.

PARKER

POWDERED METAL PARTS
ALUMINUM and ZINC
die castings

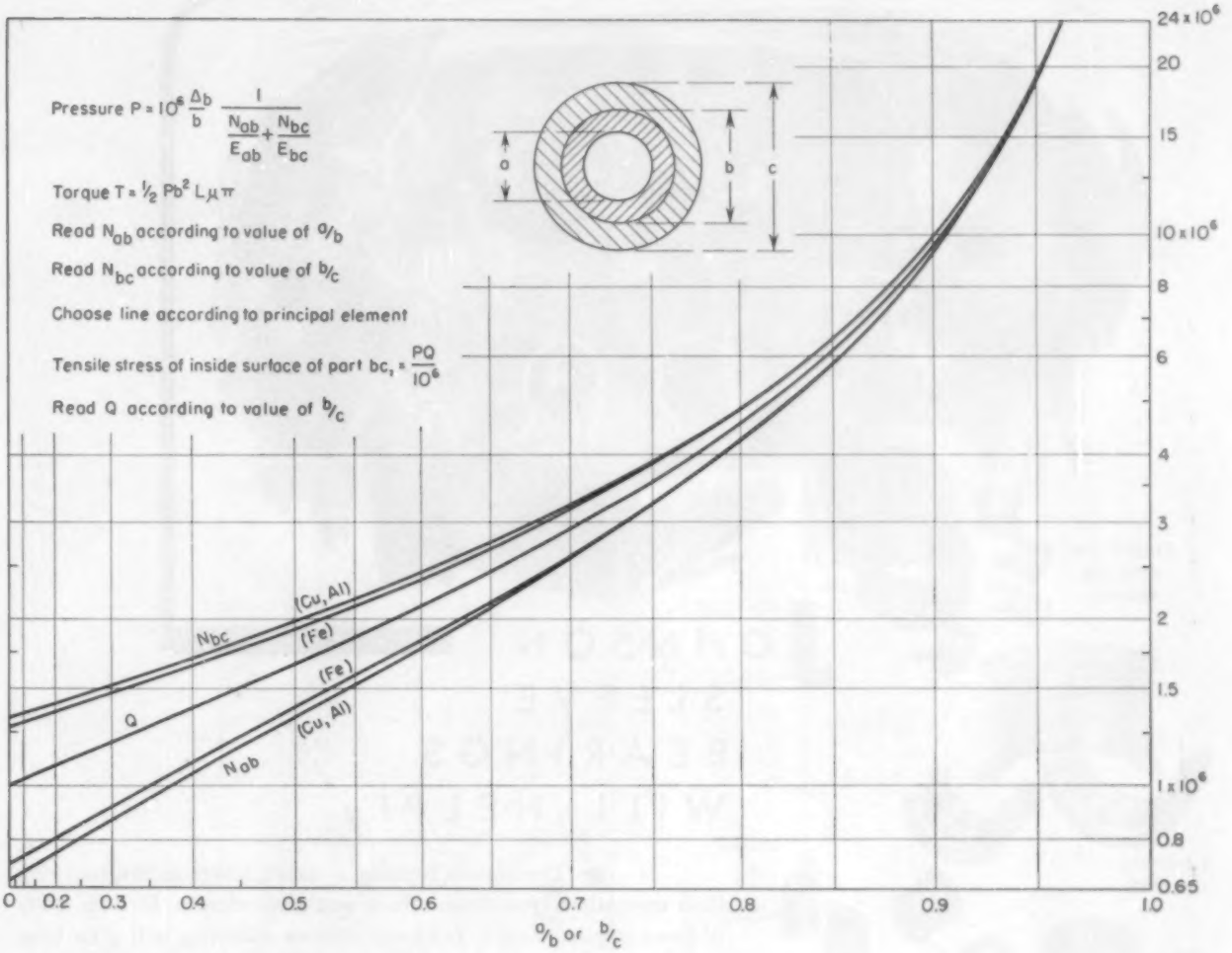

Fig. 1—Press and shrink fit variables.

(continued from page 207)

adheres strongly to metal upon contact. On the other hand, the bond between two adjacent layers of sulfur atoms is weak, so they slip easily over one another. Since no free sulfur is present it does not attack metals. Unlike graphite, the lubricating action does not depend on the presence of a film of moisture and can be used in a vacuum, while its low oxidation tendency permits its use at temperatures from about −40 to 700 F. Since it is also a dielectric lubricant, it is a nonconductor and does not attract dust.

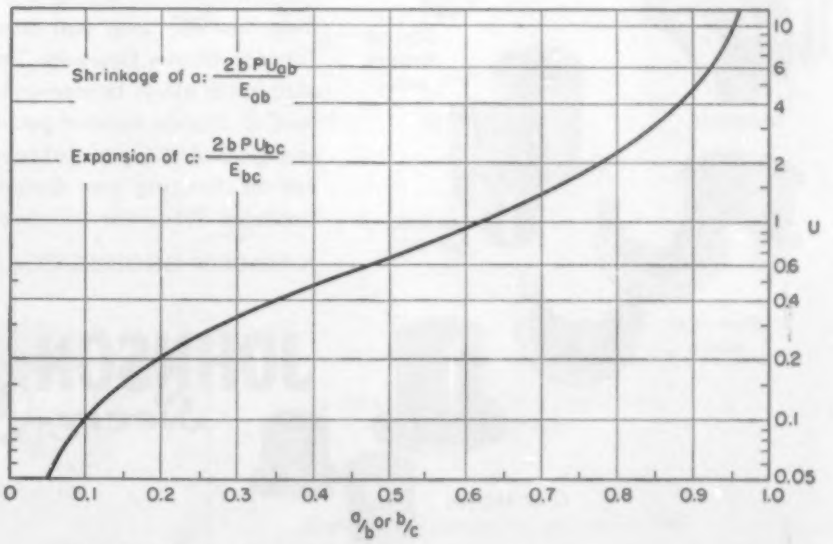

Fig. 2—Elastic change in diameter.

LOOKING AHEAD TO ECONOMIES IN PRODUCTION?

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● The sleeve bearing is much lower in original cost than any other type from which you may choose. In over 90% of your applications a Johnson Sleeve Bearing will give long, trouble-free service . . . in many instances, for the life of the product in which it is installed. It is quiet, corrosion resistant, conformable, and simple in construction. Possibly you are buying more bearing than you need. You can simplify and save with Johnson Sleeve Bearings. They are available in cast bronze, cast aluminum alloy, bronze-on-steel, aluminum-on-steel, babbitt on steel or bronze, molded powder metal (pre-cast bronze powder), and graphited types. Johnson engineers will gladly consult with you on changing your designs to use economical Johnson Sleeve Bearings. Write for an appointment.

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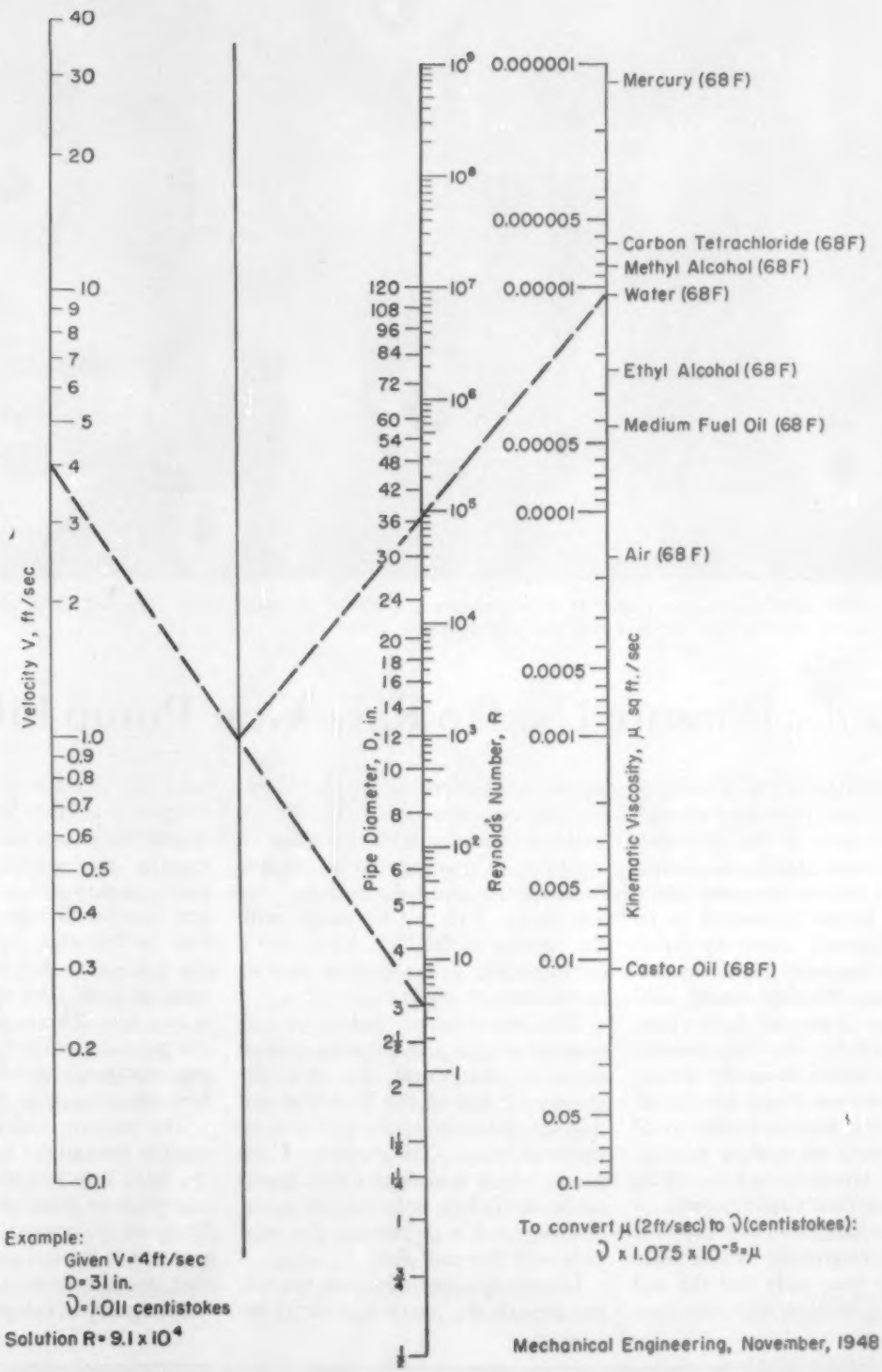
Reynolds Number Chart

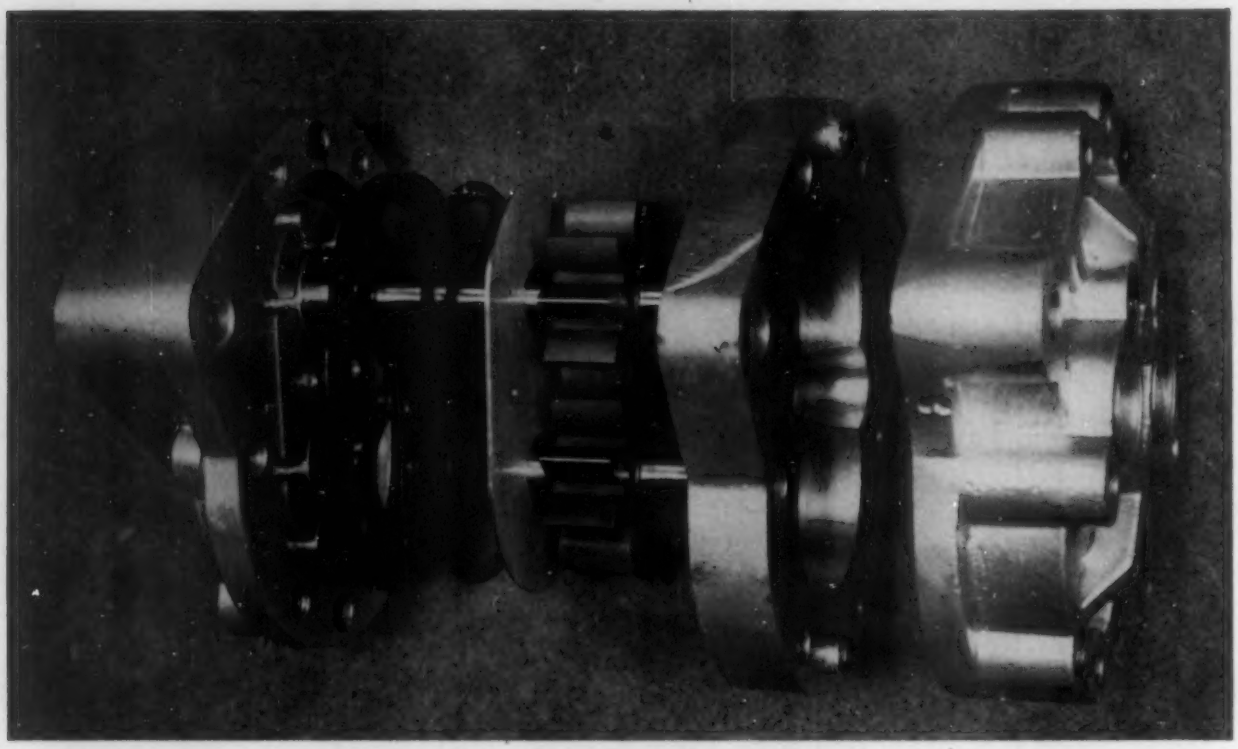
GEORGE LOWEKE
Wayne University



Example:
Given V = 4 ft/sec
D = 31 in.
ϑ = 1.011 centistokes
Solution R = 9.1×10^4

To convert μ (2 ft/sec) to ϑ (centistokes):
$\vartheta = 1.075 \times 10^{-5} \mu$

Mechanical Engineering, November, 1948



EXPLODED VIEW of the new gear pump. It shows relative position of all major parts. The end cover plate is at the left, with die-cast groove pattern into which V-seal and anti-extrusion gasket fit.

Hydraulic Pressure Used to Raise Gear Pump Efficiency

The largest single loss of efficiency in gear pumps is due to leakage through the clearance between the gear ends and the end cover plates. It is especially serious where the gears mesh. This loss is further aggravated by increases in clearance caused by deflection due to pressure, thermal expansion and wear. For this reason, until recently, gear pumps have been thought unsuitable for high pressure (1000 psi or more) hydraulic service.

In a pump now being introduced, end clearance is kept very small at all times by means of a thin, flexible, steel-backed, bronze wear plate. This is kept in contact with the gears by hydraulic pressure, which is carefully controlled in magnitude. A thin space between the wear plate and the end cover plate is divided into area compartments by a specially molded V-seal and anti-extrusion gasket. The V-seal, made of synthetic rubber, consists of a pattern of V-section fences arranged concentrically and radially around the gear shafts. This part fits snugly, with the opening of the "V" down, into a corresponding groove pattern die cast in the end cover plate.

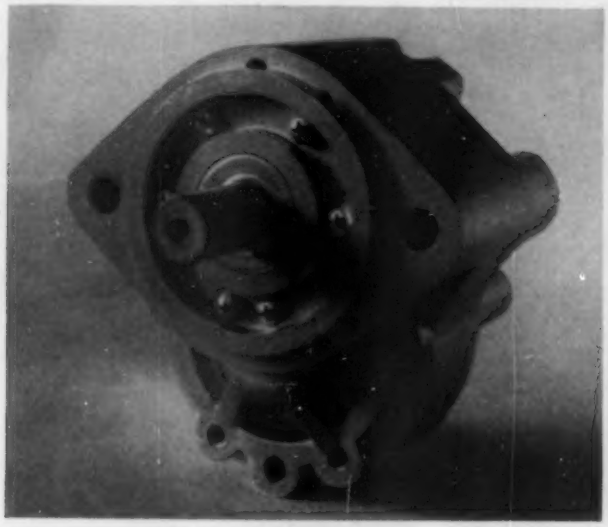
The anti-extrusion gasket, of rectangular section and the same over-all shape as the V-seal, fits into the grooves on top of the V-section and it is in contact with the back side of the wear plate. The purpose of the gasket, which is made of either harder rubber or Teflon, is to prevent extrusion of the V-seal between the wear plate and the end plate.

In operation, pressure from the output area of the pump is directed behind the interconnecting pattern of V-grooves in the V-seal, forcing it against the gasket and wear plate and forming the several compartments. Each compartment is connected to the gear chamber through a small punched hole in the wear plate. As a result, the pressure is said to be nearly the same on both sides of the wear plate in any area. This is true even though the pressure inside the gear chamber increases progressively as the oil moves from the suction to the output areas.

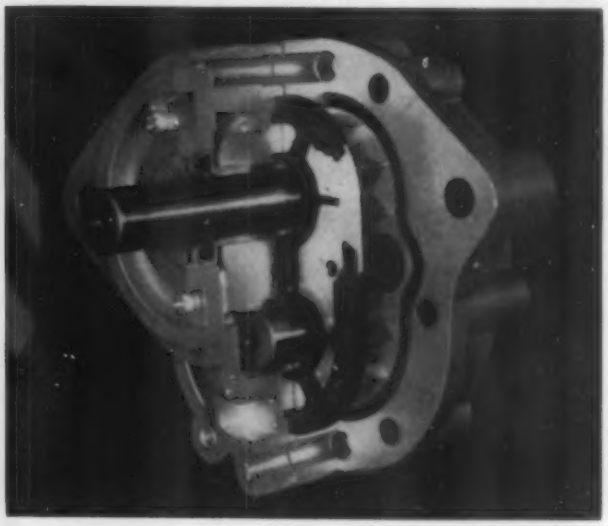
The pressure within each compartment is determined by the position of the small hole in relation to the pressure gradient inside the gear chamber. By carefully locating these holes, the pressures in the compartments are such that, together with the force of the output pressure behind the seal, there

AND MATERIALS

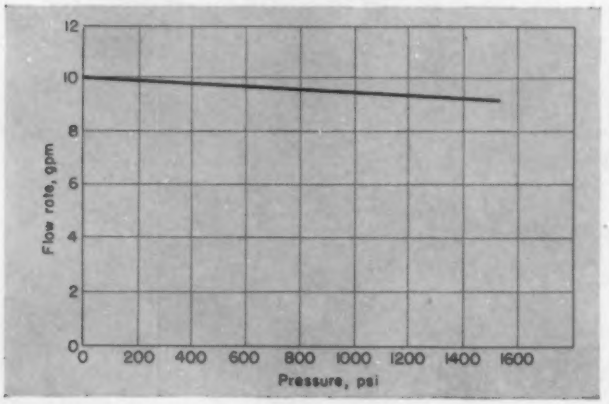
SPECIFIED BY PRODUCT ENGINEERS



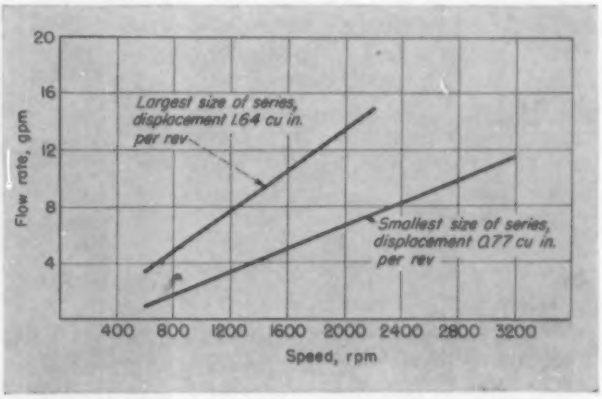
GEAR PUMP MODELS to be produced first will have displacements of 0.77, 1.0, 1.3 and 1.65 cu in. per revolution.



CUTAWAY VIEW shows relative assembled positions of V-seal, anti-extrusion gasket, wear plate and gears.



PRESSURE-OUTPUT CURVE. To establish this data, Texaco PC oil at 150 F was used, viscosity 100 SSU, Speed 1770 rpm.



SPEED-OUTPUT CURVE was established with a pressure, 1500 psi; oil viscosity, 100 SSU; temperature 150 F.

is just enough net force on the wear plate to deflect it snugly against the gears. Consequently, the clearances on both ends of gears are always held to a minimum regardless of deflection of the case due to pressure, thermal expansion, or wear.

As a result, the volumetric efficiency is consistently higher than that of a conventional gear pump. Typical sample units are reported to have shown volumetric efficiencies running as high as 92 per cent at 1500 psi operating at 1800 rpm with oil of 100 SSU.

The design permits the use of inexpensive, low friction, high lead steel-backed bushings, pressed in and bored for accurate permanent alignment. Since the wear plate takes up clearance by deflecting rather than moving inside the gear chambers, an inexpensive die-punched piece replaces the heavy machined wear plate used in other designs. The die-cast aluminum case also contributes to manufacturing economy.

Weight of the new gear pump is about 6½ lb. Dimensions are width, 5⅜ in.; height, 5½ in.; depth 3¾ to 4½ in. Mounting is the standard SAE magneto. Maximum recommended operating pressure is 1500 psi. Present series of four models (displacements of 0.77, 1.0, 1.3, 1.65 cu in. per revolution) will be available with a variety of porting arrangements. Pump can be supplied for clockwise or counterclockwise operation. Industrial Hydraulics Div., Cessna Aircraft Co., Hutchinson, Kansas.

For more information—
Circle 1, inside back cover

CONTINUED ON PAGE 216

Spherical Steel Shot Transmits Power

At normal operating speeds this dry "fluid drive" does not slip. In the case of an overload, it is slippage which gives protection.

Originated in Europe, where thousands of installations are said to have already been made, the new drive has been redesigned to American standards and will be available from stock. It is claimed that the device will have wide application for industrial drives involving heavy inertia and shock loads on such equipment as compressors, centrifuges, conveyors, crushers, and machines used in metalworking plants, textile mills and the oil fields.

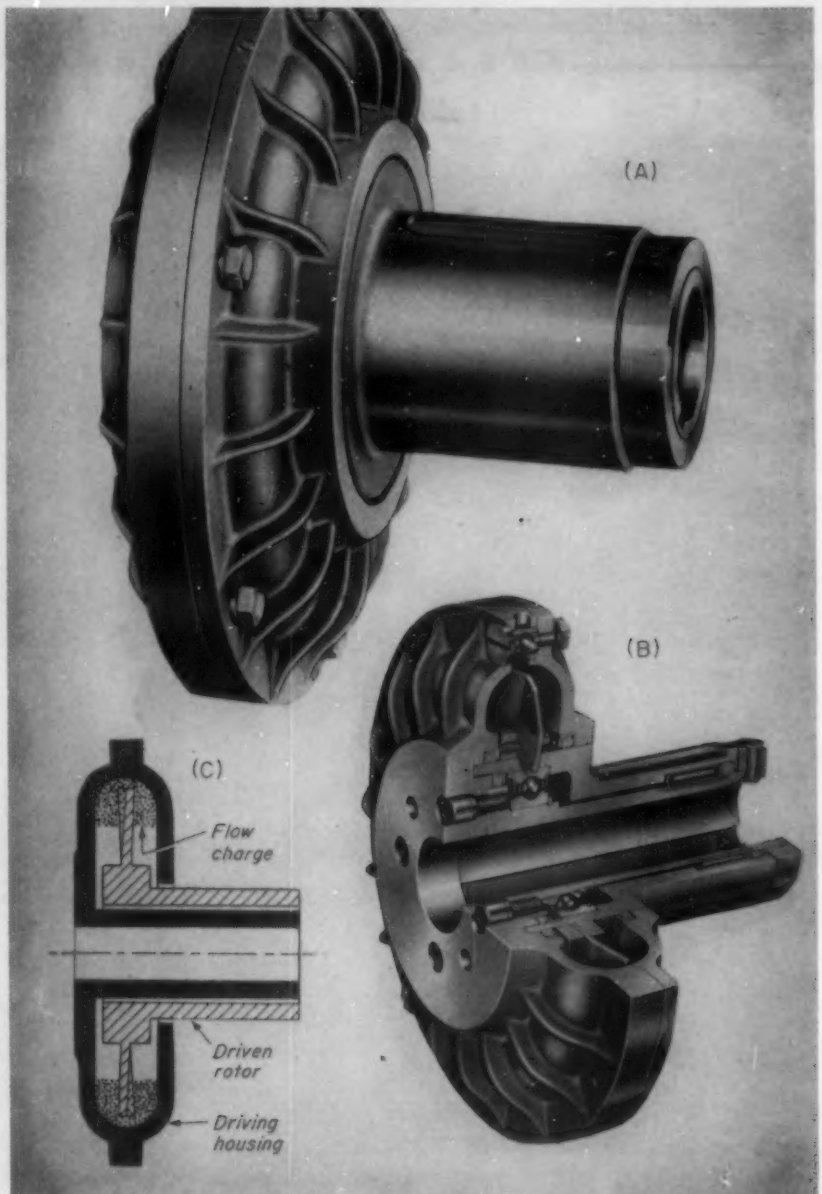
The drive consists of a housing, inside of which a rotor is free to turn concentrically. Between the two are fine particles of spherical steel shot, called the "flow charge," which acts very much like a fluid. It is the flow charge which transmits power from the housing to the rotor. This flow charge is easy to seal in, has a high density and can stand relatively high temperatures.

A motor or other power source is connected to the housing, and starts it turning at no load. The flow charge is thrown to the circumference of the housing, is compressed by centrifugal force and revolves with the housing.

The rotor, connected to the load, is started and accelerated by the friction and wedging action of the revolving flow charge. Rotor and housing reach identical speeds. The unit operates with zero slippage between motor and load at normal running speeds.

In case of an overload, before damage is caused, the rotor slips relative to the housing, overcoming the friction and wedging action of the flow charge. A thermal switch is optional equipment. It automatically cuts the electrical circuit if an overload persists.

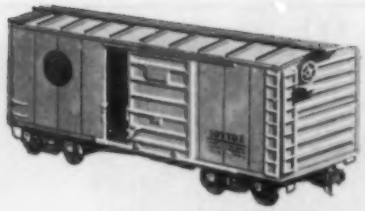
The amount of the flow charge determines the torque capacity. Because it is easy to vary the amount of this charge, the new drive will give the exact starting torque needed for anything from the smoothest to the fastest start. Slipping can be set to begin at anywhere from as low as a gentle 20 per cent over full-load torque to as high as peak motor torque. During starting and overload periods the current draw is at a minimum because with the standard setting the motor is never pulled down to less than 90 per cent of synchronous speed. Four sizes of the new drive are being offered now, ranging from 3 to 30 hp at 1800 rpm. A type of unit designed for mounting directly on motor shafts and adapted for sheaves is planned, as well as one for straight line drives. Dodge Mfg. Corp., Mishawaka, Ind.

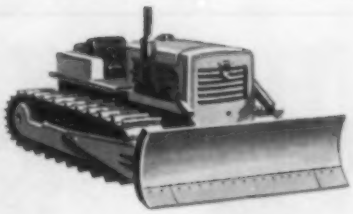


(A) Four models of the new drive are to be available, ranging from 3 to 30 hp at 1,800 rpm. (B) Cross-sectional view of new drive shows chamber in which amount of steel shot required for the desired torque is placed. (C) Power transmission is accomplished in this unit by the centrifugal force and wedging action of steel shot forced against circumference of the housing.

For more information—
Circle 2, inside back cover

CONTINUED ON PAGE 218





MAKE IT WEIGH LESS

N-A-X

HIGH-TENSILE STEEL

MAKE IT LAST LONGER

You can design light weight, longer life, and economy into your products by including N-A-X HIGH-TENSILE in your plans.

- It is 50% stronger than mild steel.
- It is considerably more resistant to corrosion.
- It has greater paint adhesion with less undercoat corrosion.
- It has high fatigue life with great toughness.
- It has greater resistance to abrasion or wear.
- It is readily and easily welded by any process.
- It polishes to a high lustre at minimum cost.

And with all these physical advantages over mild carbon steel—it can be cold formed as readily into the most difficult shaped stamping.

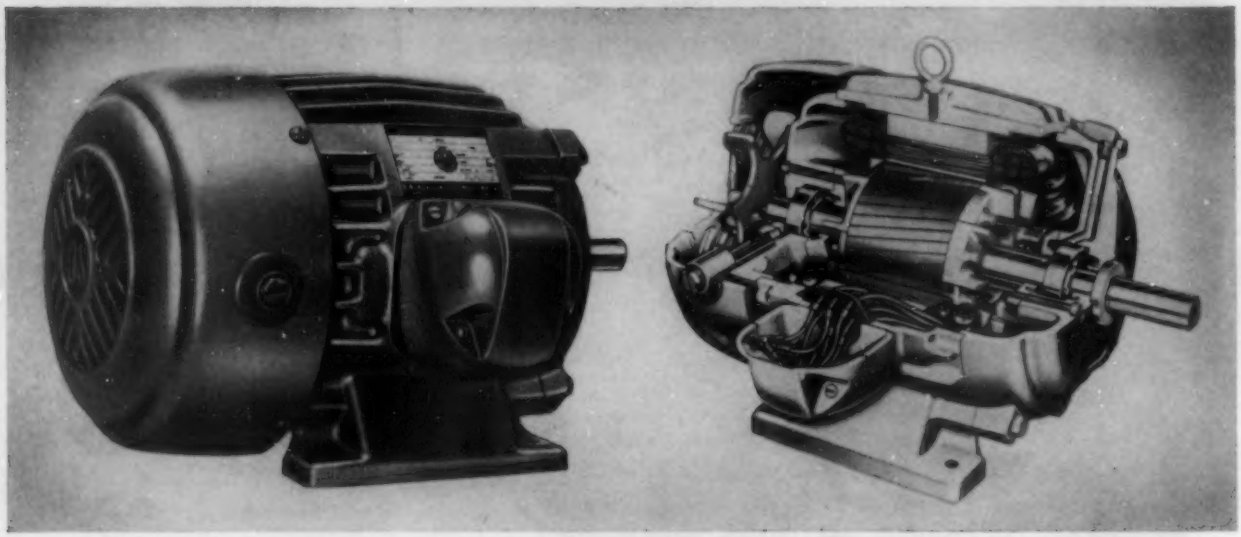
When you next start to redesign, get the facts on N-A-X HIGH-TENSILE. It's produced by Great Lakes Steel—long recognized specialists in flat-rolled steel products.

N-A-X Alloy Division

GREAT LAKES STEEL CORPORATION

Ecorse, Detroit 29, Mich. • A Unit of

NATIONAL STEEL CORPORATION



Totally Enclosed Motors of 1 to 10 Hp Ratings

An improved motor for duties requiring a completely enclosed unit and conforming to the dimensional standards recently adopted by NEMA has been placed in production. It has been designed more compactly than previous types and the same horsepower is provided in less space, according to the manufacturer.

No general disassembly is required to gain access to the bearings. This new motor, designated as Type J, is engineered for operation where fumes, dusts, and moisture are prevalent. The externally exposed surfaces are of cast iron. The frame is a solid cast structure, heavily ribbed around the entire unit for added strength and rapid heat dissipation.

The stator core is pre-wound and the windings are asbestos-protected. The rotor is electronically balanced. An improved slinger seal on the shaft adjacent to the bearing prevents intrusion of moisture to the interior. The ventilating fan is housed within a protective cast-iron fan guard and has a split hub to facilitate assembly. A new type split-dome conduit box is of heavy cast iron. Leads are uniformly positioned, lugged and clearly identified. This box can be rotated to any of four positions.

The ball bearings are equipped with a type of transverse lubrication to permit thorough purging of old grease when and if desired. All castings are normalized. Type J is being produced in ratings from 1 to 10 hp and may also be had in the fanless type for lower ratings from 1 to 1½ hp. U. S. Electrical Motors Inc., Box 2058, Los Angeles 54, Calif.

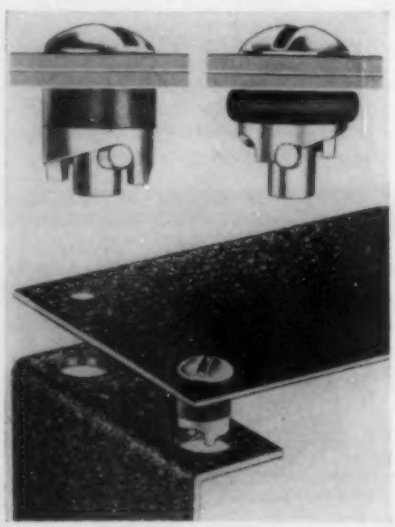
For more information—
Circle 3, inside back cover

Panel Fastener Stops Rattles, Isolates Vibration

A half-turn panel-to-base fastener developed by Vibrex Fastener Corp. combines the functions of a positive lock with those of an elastic isolator. The device floats an entire panel on resilient rubber.

According to the manufacturer, the fastener smothers rattles and noise, and isolates vibration and shock. In addition, it compensates for misalignment between panel and base. It is water, dust and pressure-proof. The new device can be used for fastening metals, plastics, breakable and brittle materials such as glass and ceramics, and fiber and composition board. It is expected that these mounting units will also prove applicable where a dust and moisture-proof closure is necessary. The fastener is recommended for application where noise is troublesome.

To install, the fastener is attached to a hole in a panel and locks in a plain ¼-in. dia hole in a base. Countersinking, riveting or spotwelding is unnecessary. There are no springs or



HALF-TURN COMPRESSES this panel fastener's rubber sleeve, locking it in position.

CONTINUED ON PAGE 220

EASY . . . INEXPENSIVE TO POST-FORM THESE PARTS WITH

New DILECTO CF-1

- *Non-After-Glow characteristic*
- *A canvas-based laminate*
- *Post-Forms to shapes in inexpensive cold molds*
- *Excellent mechanical strength*
- *Resists abrasion, has long life*
- *Easily machined and punched*

Where can you use this new canvas-based C-D-F "Post-Forming" Dilecto grade CF-1? Presently it's used for a multitude of aircraft and semi-structural parts . . . as ribbed panels, fan blades and ammunition bay liners, guards and cover frames . . . as ventilating ducts, battery box containers . . . switch covers, thermostat mounting plates, etc. CF-1 has a tremendous potential in electrical as well as other industries because of its strength and light weight.

"Post-Forming" Dilecto CF-1 is easy to work with. Heated until pliable with infra-red, electric ovens, strip heaters or hot plates, or immersed in molten alloys or hot oil, it is then quickly placed in a cold mold and pressed or formed until cold enough to retain the desired shape. Inexpensive molds can be made from hard wood, cast or laminated plastics, steel and metal alloys. Normally C-D-F supplies Dilecto CF-1 in sheets from 1/32" to 1/4" thicknesses.

C-D-F's sales engineers (offices in principal cities) will cooperate with your designers and production experts. C-D-F also forms and fabricates Dilecto to your specifications. Write for technical bulletins describing Dilecto CF-1 as well as other grades of Post-Forming Dilecto.

NON-AFTER-GLOW — Post-Forming Dilecto CF-1 incorporates special chemicals in the varnish that produce no apparent after-glow once an ignited specimen has been extinguished. This product complies with the SAE-Aeronautical Material Specification AMS-3605, latest revision.

SILICONES, TOO — C-D-F offers other post-forming grades of laminated Dilecto: Grade GB-SF is a glass-base Silicone laminate furnished in a semi-cured state for forming pieces where high heat resistance and low dielectric losses are required. Can be formed into armature slot insulators, rectangular coil forms, primary-secondary cylindrical or rectangular insulators for dry type transfomers, etc. Grade XF Dilecto is a paper-base grade for mechanical applications where electrical properties are secondary.

THE NAME TO REMEMBER CDF FOR POST-FORMING DILECTO LAMINATED PLASTICS

Continental-Diamond Fibre

CONTINENTAL-DIAMOND FIBRE COMPANY

NEWARK 40, DELAWARE

grommets to install and no separate receiving unit is required.

Locking action results from the controlled expansion of a sleeve made from special rubber, said to exert a locking pressure of over 150 lb. A half-turn locks or disengages the unit. The locking mechanism is sturdy and indestructible.

A variety of types is in production, including latches for cabinet doors and drawers, anti-vibration mounts with quick release, gasket-holding fasteners and special instrument types which combine bottom panel holder and cabinet bumper in a single fastening unit. General Tire & Rubber Company, Wabash, Indiana.

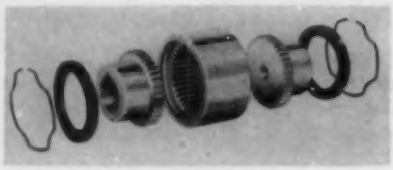
For more information—
Circle 4, inside back cover

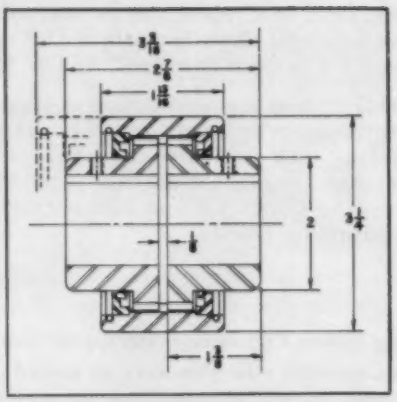
MECHANICAL COMPONENTS

Powdered Steel Shaft Coupling

For connecting ½ in. to 1¼ in. shafts, this coupling is of the gear type and has a one-piece smooth sleeve. Together with the hubs, this sleeve is made of powdered steel. Price is said to be low enough to put this coupling unit in competitive position with chain, pin-and-bushing and flexible disc or grid designs. It can be run at higher speeds and both assembly and uncoupling require only seconds.

The coupling is manufactured in the one size only. Asbestos-neoprene seals are used and snap rings are spring steel. All bore tolerances are 0.001 to 0.000. Initial grease lubrication is asserted to last up to two years. Sier-Bath Gear & Pump Co., Inc., 9252 Hudson Blvd., N. Bergen, N. J.





For more information—
Circle 5, inside back cover

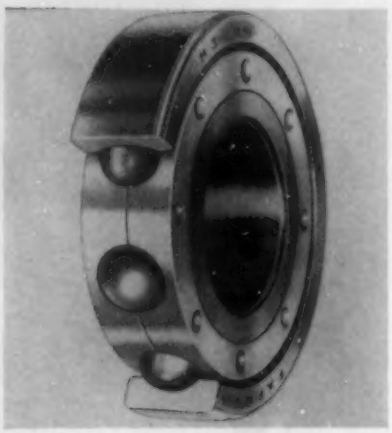
Miniature Viscous Damper

This hydraulic damper has been developed to furnish moderate amounts of angular rate damping in mechanical systems where small size and weight, and also minimum friction, are of primary importance. It features ball bearing shaft suspension. The entire housing is anodized aluminum alloy, and the vane shaft is hardened stainless steel. The unit is sealed from atmospheric effects.

Damping is adjustable over a wide range by means of a needle valve arrangement. No temperature compensation is provided, but use of silicone damping fluid keeps temperature effects to a minimum.

Damping rate is 0.5 to 25 in-lb/rad/sec at 70 F. Maximum permissible torque is 15 ft-lb. Weight of unit is 9 oz (filled). Haines Gauge Co., Inc., Henderson and Shoemaker Roads, Bridgeport, Pa.

For more information—
Circle 6, inside back cover



Ball Bearings for Woodworking Machinery

Designated the M300 series, these bearings are a single row, radial type made with two types of retainers, depending on the size of the bearing. One is a composition type, the other a machined bronze retainer. Fafnir Bearing Co., New Britain, Conn.

For more information—
Circle 7, inside back cover

Stainless Weld and Clinch Nuts

Pilot, countersunk weld nuts and clinch nuts in stainless steel are being made both with and without a self-locking arrangement. Sizes available at present are 10-32 through ¼ in., fine and coarse threads. Grip Nut Co., 310 S. Michigan, Chicago 4, Ill.

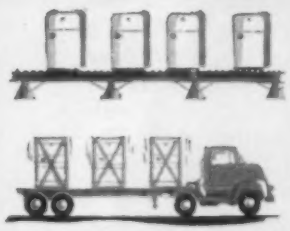
For more information—
Circle 8, inside back cover

Precision Ball Bearings With Single or Double Side Shields

These bearings have metallic shields which may be removed for cleaning. Oil or grease lubrication can be specified. Available types include straight

CONTINUED ON PAGE 222

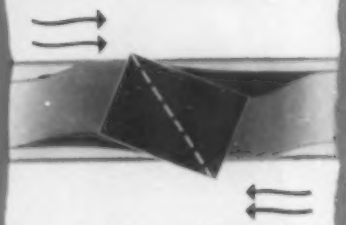
Why SHAKEPROOF® LOCK WASHERS defeat vibration!



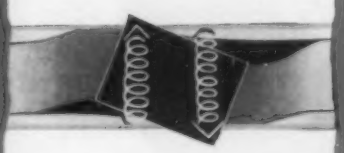
The purpose of lock washers is to keep screws and nuts tight.

Shakeproof Lock Washers provide positive locking action that ordinary washers cannot give.

Only Shakeproof Lock Washers have these exclusive tapered-twisted teeth . . .

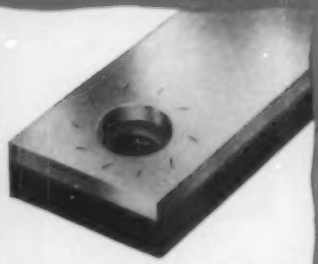


where each tooth is a strut to resist all loosening rotation of threaded fastening.



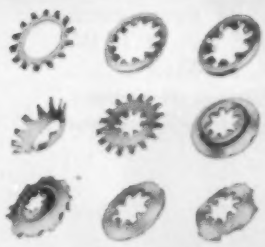
Spring tension forces the edges of each tooth to bite deeper.

Shakeproof Lock Washers lock tighter as vibration increases . . .



and the locking power of each tooth is multiplied by the number of teeth.

Their exclusive mechanical lock resists loosening as no other lock washer can!



To meet the majority of your locking needs, there are nine standard types.

The variety and styles of "specials" to meet individual requirements are unlimited!

For maximum savings, buy Shakeproof Lock Washers pre-assembled on screws as SEMS.

Pre-assembled on nuts, Shakeproof Lock Washers save time—specify KEPS®.

Free Sample Kit

Now . . . make your own tests! See for yourself how SHAKEPROOF Lock Washers can save time in assembly and protect the quality of your products. Write for your free sample kit today!

SHAKEPROOF

"Fastening Headquarters"®

DIVISION OF ILLINOIS TOOL WORKS

St. Charles Rd., Elgin, Illinois - Offices in Principal Cities

In Canada: Canada Illinois Tools Limited, Toronto, Ontario

WORLD'S BROADEST LINE OF MASS-ASSEMBLY FASTENINGS

and flanged outer rings. Most sizes are being scheduled in stainless steel (type 440) at no increase in price over chrome steel (SAE 52100). Tolerances are ABEC 5 or better. Sizes range upward from $\frac{3}{16}$ in. bore, $\frac{1}{2}$ in. overall dia. New Hampshire Ball Bearings, Inc., Peterborough, N. H.

For more information—
Circle 9, inside back cover

Self-Aligning Rod End Bearings

These spherical bearings are said to reduce lost motion in linkages and to withstand excessive vibration. They carry heavier loads than anti-friction types since they have a greater surface supporting area. Made of one-piece ball and one-piece race, they are available in sizes from $\frac{3}{16}$ to $\frac{3}{4}$ in. bore and larger with capacities of radical ultimate loads from 1670 to 15,600 lb and higher. Southwest Products Sales Corp., 1707 S. Mountain Ave., Duarte, Calif.

For more information—
Circle 10, inside back cover

Cartridge Roller Bearing

An integral unit, this bearing consists of outer race, roller assembly, retaining disc and seal. Besides substituting for plain bushings, it can be used in caster and wheel housings, and in gear boxes or gear drives.

Presently available are bearings to fit $\frac{1}{2}$ to $1\frac{3}{8}$-in. shafts and $1\frac{1}{8}$ to $2\frac{1}{2}$-in. housing bores. Within these dimensions are the following types of roller assemblies: (1) a type N bearing with hardened but unground rollers for use on shafts of 54 Rc min; (2) a type UN bearing with either unhardened and unground rollers for use on unhardened shafts, or with hardened and ground rollers. These assemblies are made up of solid cylindrical rollers aligned and supported by rigid cage construction. Rollway Bearing Co., 541 Seymour St., Syracuse, N. Y.

For more information—
Circle 11, inside back cover

Vibration Mount For Instruments

A neoprene-insulated mounting for laboratory, scientific, and precision manufacturing equipment dampens vibration and insulates against shock. It will also serve as a means of leveling the equipment that it supports. The conical shape of the neoprene element is said to be the reason that the mounting can be used at any load from 10 up to 50 lb per mount. A threaded stud secures and levels the equipment, as well as providing adjustment for height. A hole at the base is for a hold-down bolt, if required. Dimensions are: diameter, $2\frac{3}{8}$ in.; height, $1\frac{1}{4}$ in.; adjustment for height variation, 1 in. Bushings, Incorporated, 4358 Coolidge Highway, Berkeley, Michigan.

For more information—
Circle 12, inside back cover

All-Metal Shock and Vibration Control Mountings

This mount can withstand dynamic loads as great as 50 G and static loads greater than 100 G, according to its maker. The load is carried entirely by knitted stainless steel wire mesh cushions. Robinson Aviation, Inc., Teterboro, N. J.

For more information—
Circle 13, inside back cover

Adjustable-Speed Drives

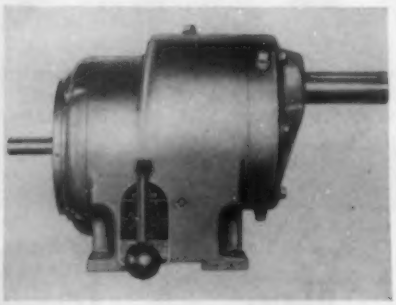
This drive permits a speed variation of as much as 100 per cent at horse-power capacities said to be comparable to former drives having two or three belts. As much as 30 hp is safely transmitted. The new drive consists of a single-groove, wide-range, adjustable-diameter sheave with double-taper hub construction. The "Q" groove sheave has a pitch diameter range from 5.0 to 8.5, "R" groove from 5.5 to 10.0 and "W" from 5.5 to 11.0. American Pulley Company, 4200 Wissahickon Avenue, Philadelphia 29, Pennsylvania.

For more information—
Circle 14, inside back cover

Miter Gear Drive

This right angle gear drive is available with a standard ratio of 1:1 and furnishes up to 2 hp at 1800 rpm. Normally available with a right-hand extension, it may also be furnished with upward or downward extension, hardened gears or special ratio. The Model RA 225 is totally enclosed in a cast-iron housing. It has a base $6\frac{1}{4}$ in. wide and a height of $5\frac{13}{16}$ in., with extensions 6 in. from center. Grant Gear Works, Inc., 171 W. Second St., Boston 27, Mass.

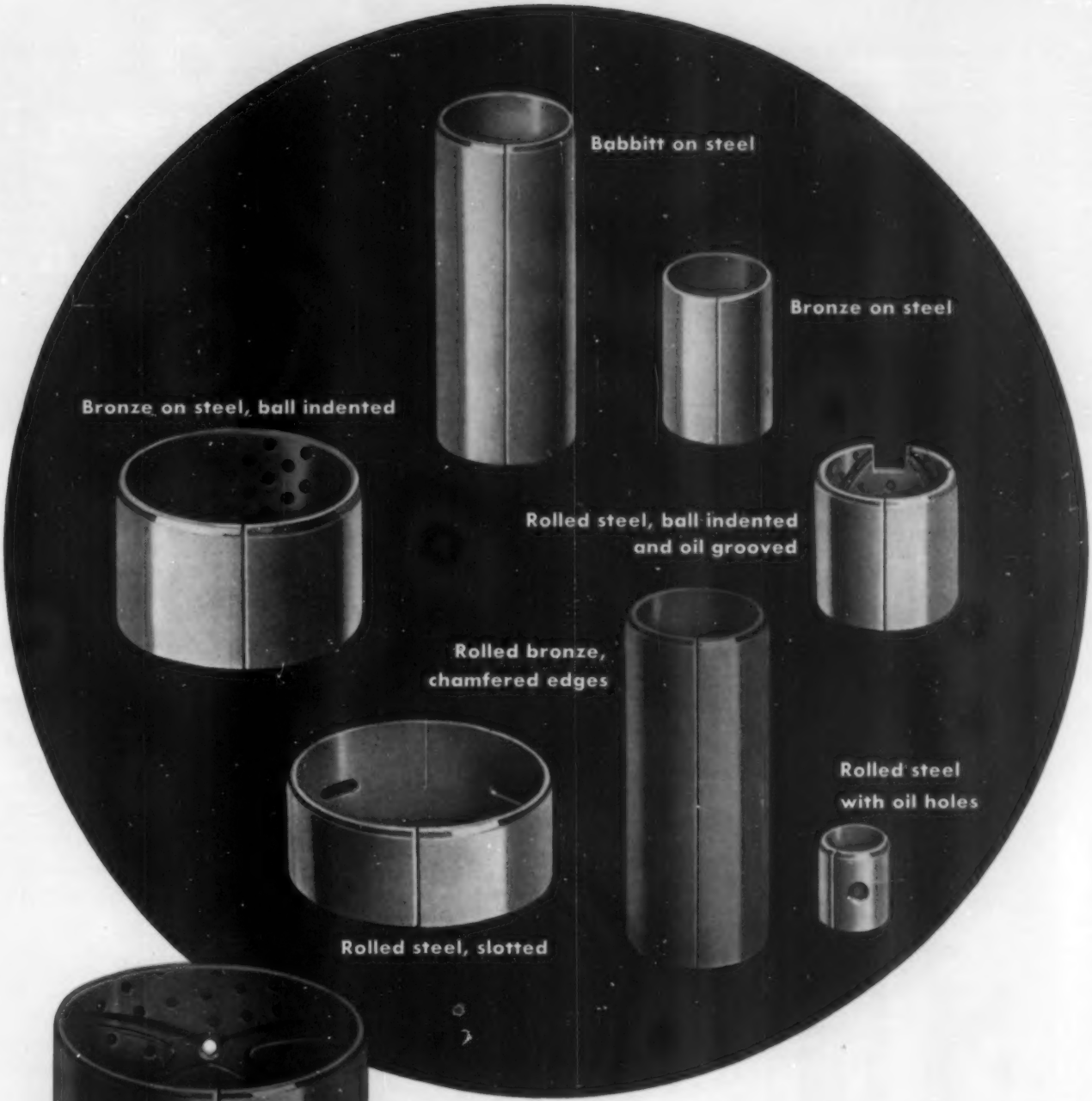
For more information—
Circle 15, inside back cover

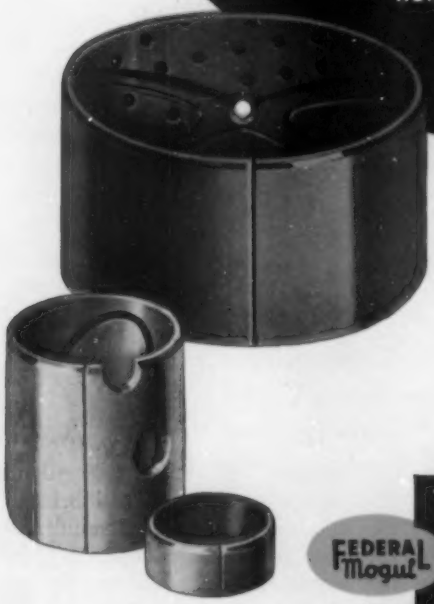


Gearshift Drive

This sliding gear transmission is built with a capacity of 5 hp at 1800 rpm input and provides four constant horsepower output speeds when used with a single speed motor. Eight output speeds are developed when used

CONTINUED ON PAGE 224


Babbitt on steel
Bronze on steel
Bronze on steel, ball indented
Rolled steel, ball indented and oil grooved
Rolled bronze, chamfered edges
Rolled steel with oil holes
Rolled steel, slotted



Rolled, split bushings, bimetal or plain, are real money savers. Bimetal bushings give bearing performance at bushing costs for many applications. Plain bushings save money in hundreds of uses from business machines to bicycles. Both types available in a wide variety of sizes, with oil holes, grooves, notches, windows, straight lock or special seams. Quality control. Engineering service.

FEDERAL-MOGUL CORPORATION, 11043 Shoemaker, DETROIT 13, MICHIGAN

FEDERAL Mogul since 1899

FEDERAL-MOGUL

Also sleeve bearings in many designs and sizes; cast bronze bushings; washers, spacer tubes, precision bronze parts and bronze bars.

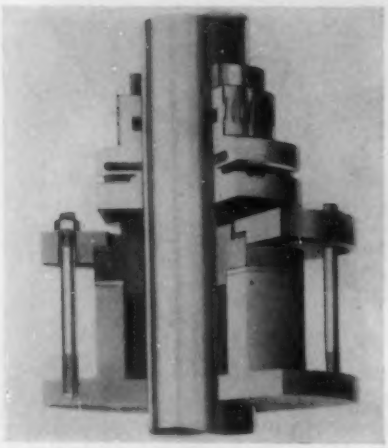
with a two-speed motor. The Type R3DC drive has the following primary gear ratios: 4.15 : 1, 3.15 : 1, 1.85 : 1 and 1 : 1. In addition, eleven optional secondaary gear ratios are available, ranging to a maximum of 2.25 : 1. Depending on the speed of the motor used with this new transmission, the speed range runs from a low of 93 to a high of 1730 rpm (full-load). Lima Electric Motor Co., 131 Findlay Road, Lima, Ohio.

For more information—
Circle 16, inside back cover

Porous Bronze Oil Filter

A cylindrical filter, originally developed for use on cars, removes particles as small as 39 millionths of an inch, according to its maker. It is said that the unit never needs replacing. An occasional cleaning restores it. Engine Products Mfg. Co., 5801 E. Beverly Blvd., Los Angeles, Calif.

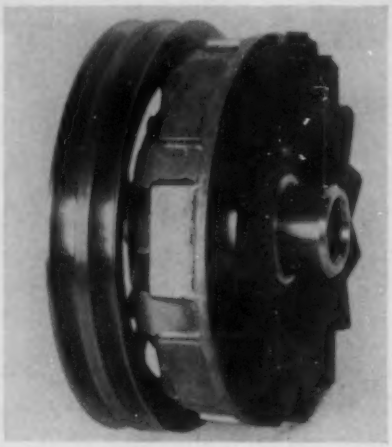
For more information—
Circle 17, inside back cover



Rotating Mechanical Seal

An external rotating mechanical seal for pump or agitator shafts makes use of a balanced bellows made of Teflon. The seal rotates with the shaft. The only bearing surface is between rotating and stationary faces. Extremely low friction load on shaft insures lower starting toque and power cost. No scoring of shafts is possible and shafts already scored by other seals or packing can be satisfactorily sealed. This mechanical seal is being manufactured in standard sizes from $\frac{7}{8}$ to $2\frac{1}{8}$ in. United States Gasket Co., Camden 1, N. J.

For more information—
Circle 18, inside back cover



Speed-and-Torque-Metering Coupling

When placed between the engine and driven accessories, this coupling is said to act as a speed control, allowing driven accessories to operate at top efficiency over a wide range of driving speeds, but preventing their absorbing unnecessary horsepower from the engine. The coupling is made of three elements: the inner drum or driving source, the outer housing and the frictional control unit.

Operated directly by engine power, the inner drum's rotation depends entirely on engine speed, increasing or decreasing as engine speeds up or slows down. The outer housing, fitted with a V-belt, drives the accessory. Between the inner drum and the housing is the frictional control, a series of blocks held in place by springs. Lipe-Rollway Corp., 806 Emerson, Syracuse, N. Y.

For more information—
Circle 19, inside back cover

Slip Clutch Assembly

A slip clutch assembly that is adjustable in torque transmits from $\frac{1}{4}$ to 10 oz.-in. torque through three ground cork faces. The gear face will slip continuously when the set static friction is exceeded.

The unit is designed for three basic shaft sizes, $\frac{1}{8}$, $\frac{5}{16}$ and $\frac{1}{4}$ in., and has stainless steel setscrews for holding and sub-drill holes for fixed pinning. Standard stock pitches are 48, 64, 72 and 96 pitch in 20 deg pressure angle in stainless steel or aluminum. A $14\frac{1}{2}$ deg pressure angle gear is available. Pig Design Corp., 160 Atlantic Ave., Lynbrook, N. Y.

For more information—
Circle 20, inside back cover

Oil Filtering Cartridge

A filter cartridge said to have tremendous filtering area, low pressure drop and high dirt storage capacity is available in two types, F-718 and FW-718. The density of filter paper used in these standard cartridges results in removal of particle sizes down to 5 micron.

Being made of cellulose, these cartridges are suitable for filtering straight mineral oil or heavy duty detergent oils without removing the detergents and oxidation inhibitors. Hilliard Corp., W. 4 St., Elmira, N. Y.

For more information—
Circle 21, inside back cover

Miniature Fasteners

Miniature precision hardware for electronic, printed circuit, and instruments has been developed and includes instrument screws, nuts, flat washers, split lock washers, rivets and eyelets. Circon Component Co., 17544 Raymer St., Northridge, Calif.

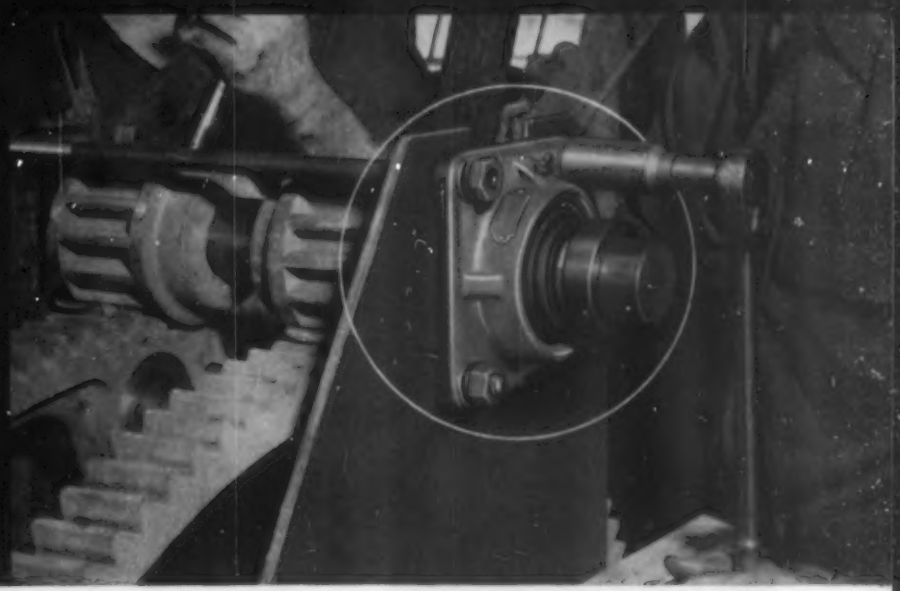
For more information—
Circle 22, inside back cover

Lubrication Unit Serves Up to 1000 Bearing Inches

This automatic unit has $4\frac{1}{2}$ gal oil capacity and uses twin lubricator heads, which may be used simultaneously or individually depending on fog requirements for the specific application. It is stated that the fog generated can be carried considerable

—CONTINUED ON PAGE 226

If assembly costs are lower



chances are

Fafnir has a bearing on it

Type LCJ Self-Aligning Ball Bearing Flange Cartridge equipped with Wide Inner Ring Mechani-Seal Bearing and Self-Locking Collar. For shaft diam.: ½" to 2 1/16".

The installation of a Fafnir Ball Bearing Flange Cartridge on the pinion shaft illustrated is being made with a socket wrench. No complicated blue prints, no costly machining, no time-consuming fitting and adjusting of bearing. Assembly costs have been cut without cutting corners.

The use of a completely-housed ball bearing unit is only part of this cost-cutting operation. The *Fafnir Unit* offers additional cost savings. Its bearing inner ring is bored for a slip fit. The eccentric cam design of its inner ring and collar makes locking action positive with a twist of the wrist. No lock nuts or adapters are needed. No adjustments of any kind are necessary. The bearing can't be cramped or overloaded when mounting.

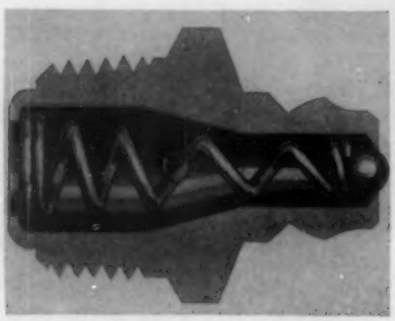
If you are looking for a way to cut assembly costs, maybe Fafnir can help you through better, more economical use of bearings. The Fafnir Bearing Company, New Britain, Conn.

MOST COMPLETE LINE IN AMERICA

FAFNIR BALL BEARINGS

distances with a minimum of precipitation in the lines and can be uniformly distributed to multiple bearing lubrication points having a maximum total of 1000 bearing inches. The lubricator measures 27 x 12½ x 16½ in. Three 2 in. fog outlets provide for flexibility of installation. Maximum oil fog output is 27 cfm at 60 psi operating pressure. C. A. Norgren Company, 3428 South Elati Street, Englewood, Colorado.

For more information—
Circle 23, inside back cover



Ball-in-Tip Grease Fittings

Ball in tip of fitting is said to keep out dirt and other foreign matter. Volume flow results from enlarged inner passage which admits more lubricant and helps cut time on important lubrication jobs. A balanced action spring retracts easily to allow maximum lubricant flow under pressure, yet holds ball firmly in sealing position at all other times. Aro Equipment Co., Bryan, Ohio.

For more information—
Circle 24, inside back cover

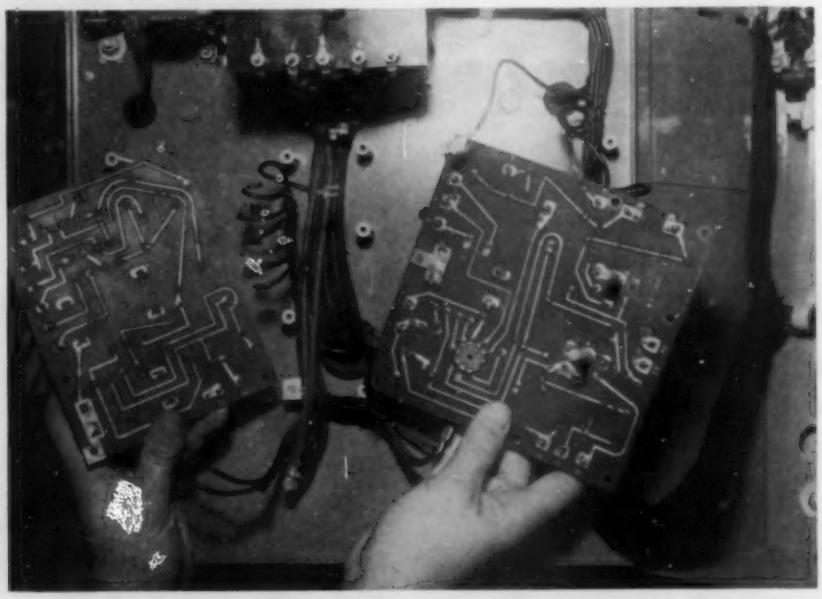
POWER AND CONTROL

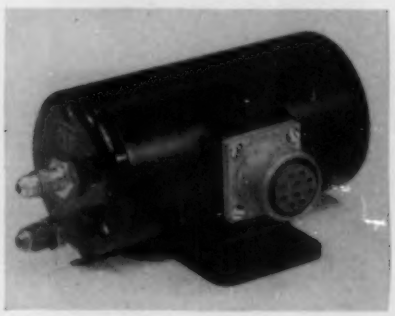
Speed Control Has Printed Circuits

Available at prices asserted to be approximately 20 per cent lower than previous models of the same type, these electronic adjustable speed drives are believed to have the first printed circuitry ever incorporated in industrial control equipment. The printboard panels can be visually inspected for circuit faults, since the panels are actually current-carrying diagrams. The panels can also be removed and replaced in a few seconds time.

The new control circuit uses a single miniature-type control tube. A-c control circuits are isolated, allowing connection with a-c drives without the use of additional relays. Power tube capacity is 40 per cent greater than full motor load current. The control is available in two ratings, ¾ to 1 hp, and 1½ to 3 hp, full wave. General Electric Co., Schenectady 5, N. Y.

For more information—
Circle 25, inside back cover





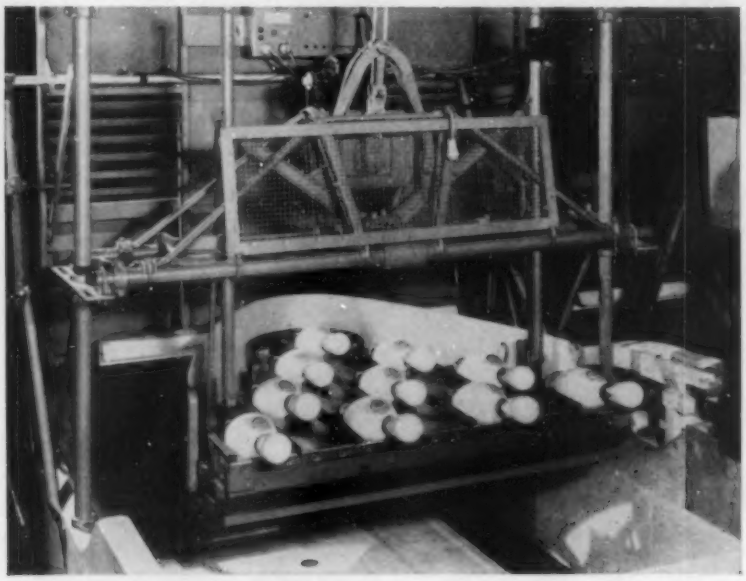
Pressure Transducer

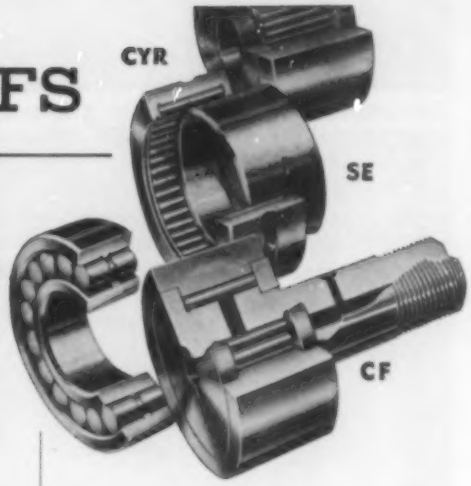
The pressure response movements of each of two metal bellows is translated into motion of sliders of paired precision potentiometers in this transducer. One bellows is connected to the dynamic pick-up line from pitot or venturi; the other bellows is exposed to pressure from the pick-up line sampling the static or ambient pressure. The electrical outputs of each of the instrument's four potentiometers are individually brought out to terminals, providing individual access to dynamic or to static data. Through an external electrical combining network, dynamic data may be automatically normalized or corrected with respect to static data as required by the application.

Potentiometer resistance ratio vs.

CONTINUED ON PAGE 228

McGILL BEARING BRIEFS





CAMROL CF bearings ADD TO SAFETY of 22,000 Brunswick-Balke-Collender semi-automatic pinsetters now in use

When the pinboys "set 'em up in the other alley" a McGill CAMROL Cam Follower helps them do the job without danger to themselves or damage to the pin-setting machine.

Known as the B-10 Semi-Automatic Pinsetter, this machine is a product of The Brunswick-Balke-Collender Company and is in use on 22,000 individual bowling lanes throughout the world.

In these machines the CAMROL CF bearing is used in the safety latch mechanism to lock the cam action and prevent the machine from recycling during pin setting. Used by the company for 4 years, the CAMROL bearing has given no trouble despite the literally millions of cycles these 22,000 machines have been operated.

CAMROL Cam Follower bearings utilize a full complement of small diameter followers with outer race and integral stud and flange custom heat treated for the ultimate in radial and shock load capacity.

Precision tolerances on all grinding surfaces with simplified lubrication minimizes internal wear and increases bearing life. Both starting and running friction are reduced to a minimum.

McGill designed and built the first Cam Follower and used 20 years of experience with thousands of applications to perfect the right Cam Follower for any cam action application.

BEARING SELECTION GUIDE

A revised 140 page Bearing Selection Guide, complete with 30 pages of vital engineering data, has been released by the McGill Manufacturing Co. Ask for Catalog No. 52.

CAMROL CF BEARING USED from BEGINNING of PRODUCTION by SCHIELD-BANTAM COMPANY

More than 5,500 cranes and excavators built by Schield Bantam since 1945 use CAMROL CF Bearings in SHIFTING COLLAR vertical swing shafts and drum clutch applications. With maintenance negligible and performance excellent the manufacturer asserts, "Using CAMROL CF Bearings offers an overall price advantage and insures maximum product quality."

PINES PRESSURE DIE HOLDER PUTS up to 18,000 POUND LOAD on CAMROL CYR BEARING

Pines Engineering Co., Inc., has used the CAMROL CYR Bearing for 6 years in tube bending machines and has never had a failure. The bearing takes the full bending moment in Pines pressure die holders that bend extra heavy pipe in sizes ranging from ¾" to 4" without scratching the tubing.

50th McGILL Anniversary

McGILL design leadership has given you these important developments

★ First full type roller bearing ★ First guided full-type roller bearing ★ First Cam Follower roller bearing ★ First sealed roller bearing

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

pressures is linear within 0.5 per cent; hysteresis within 0.5 per cent; change with temperature (−55 C to 71C) not over 0.5 per cent. Construction withstands 40G shock; departure from static calibration not over 0.7 per cent under 10G vibration up to 200 cycle. Size is $2\frac{7}{8}$ x $4\frac{1}{8}$ x $5\frac{7}{8}$ in.; weight 1.3 lb. Technology Instrument Corporation, Acton, Massachusetts.

For more information—
Circle 26, inside back cover

Constrained Bridge Magnetic Amplifier

This magnetic amplifier is suitable for the control of large power devices as well as for instrument servo applications where close packaging requires minimum size and where forced cooling is not possible. Power requirement is 115v, 400 cycle. Power consumption, on stand-by, is 1 w. Full output requires 3.5 w. Dimensions: $1\frac{7}{8}$ in. wide x $2\frac{3}{4}$ in. high x $3\frac{3}{4}$ in. long. Librascope, Inc., 808 Western Ave., Glendale, Calif.

For more information—
Circle 27, inside back cover

Transitional Line of 1 to 5 Hp Motors

To be built in the old NEMA frame sizes and dimensions, these polyphase motors will be manufactured for the convenience of those manufacturers who cannot take advantage of the new NEMA dimensions. It will be available in most popular ratings at the premium prices already in effect for motors in the old NEMA frame sizes. The premium prices will provide the new transition motors with Mylar polyester film insulation, silicone core, solid cast rotors, advanced design for sonant operation. General Electric, Schenectady, N. Y.

For more information—
Circle 28, inside back cover

Hydraulic Motors

Rated for 1000 psi continuous duty, these gear-type motors develop from 0.10 to 7.5 hp. These reversible drives are available in a variety of mountings and portings. Wisconsin Hydraulics, Inc., 316 [illegible] 30 St., Milwaukee, Wis.

For more information—
Circle 29, inside back cover

Motor-Gear Train

A smaller, lighter motor-gear train, Type 3094, is constructed so that its motor and gear assembly are not separate entities but a single homogeneous unit. Weight is $10\frac{1}{2}$ oz., $1\frac{1}{2}$ in. dia and $3\frac{1}{2}$ in. length. Ratio ranges from 3:1 to 10,500:1. Torque is 100 lb-in. at a ratio of 523:1 and 1600 lb-in. at 10,500:1. John Oster Mfg., 1 Main St., Racine, Wis.

For more information—
Circle 30, inside back cover

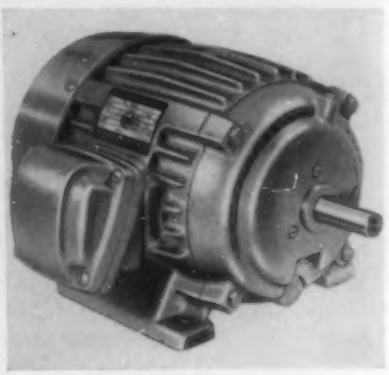
Fhp Single-Phase Motors

These capacitor-start and split-phase motors have shallower end plates to materially reduce their length. Frame is of heavy rolled steel.

Sleeve-bearing motors in the new design are lubricated by means of felt packing, cut to specified shapes and inserted in specially designed bearing housings with inner and outer seals. This type of construction effectively prevents oil leakage and assures a constant supply of oil to the bearings.

Quick-break switch and thermal overload protector are securely attached to the terminal board, which is mounted inside the stator frame. The terminal board cover can be removed by merely loosening two screws, for ease in connecting the motor to the line. Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis 14, Missouri.

For more information—
Circle 31, inside back cover



Explosion-Proof Motors 1 to 5 Hp

This motor is designed to operate in dangerous locales and is made for Class I, Group D services for highly inflammable gases and volatile liquids, and Class II, Groups F and G, for combustible dusts. It is fully enclosed, with special provision to guard against fire, dust and moisture. Type E is equipped with a sparkproof aluminum fan and Type EN is without fan. U. S. Electrical Motors Inc., Box 2058, Los Angeles 54, Calif.

For more information—
Circle 32, inside back cover

Motor for Tape Recording

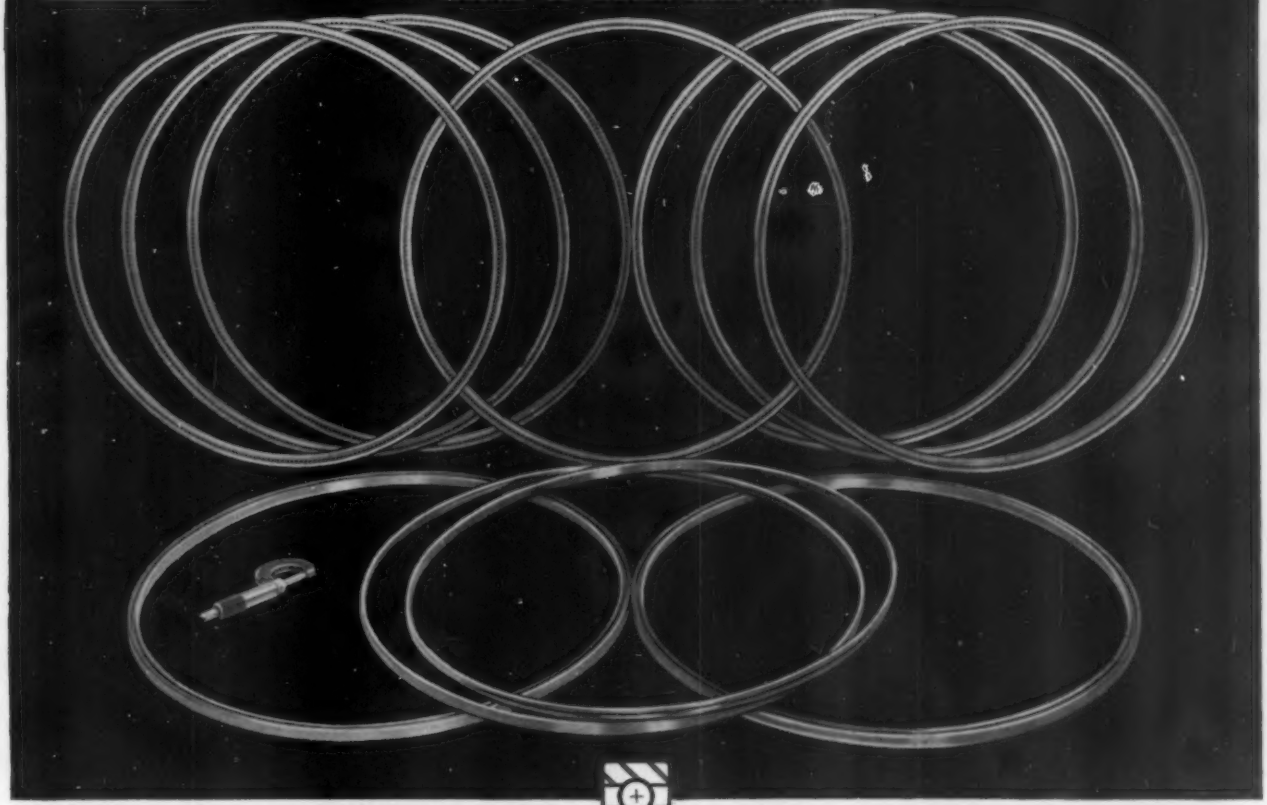
This vertically-mounted sleeve bearing motor is a permanent split capacitor type, $2\frac{7}{8}$ in. dia. It has relatively high output torque when provided with a small fan for cooling opposite the drive end. Torque rating is 4

CONTINUED ON PAGE 230

Contact KAYDON Muskegon

FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER

KAYDON BALL RADIAL BEARING — 16.875" x 17.625" x 0.375"
DESIGNED FOR PRECISION RADAR MOUNTS



ACTUAL SECTION: ONLY 3/8" x 3/8"

NET WEIGHT: 1 pound, 10 ounces

KAYDON REALI-SLIM--World's thinnest bearings provide precision answer for electronic applications

Precise Thin-Section bearings on a production basis! That's why the electronics industry makes KAYDON its headquarters for extra-light, thin-section bearings. A perfect example is this Reali-Slim 16.875" x 17.625" x 0.375" ball radial bearing.

If you're manufacturing electronic equipment that includes rotating parts, there's a Reali-Slim bearing designed to meet your requirements starting with 1/4" cross section and 1/4" width—either in small or large diameters.

Fortified with engineering know-how, years of manufacturing skill and electronic application experience, KAYDON has modern facilities for metallurgical analysis, microscopy, physical testing, atmospheric controlled heat treating, hardening, as well as sub-zero stabilizing. This all adds up to more compact, more precise, lighter equipment with built-in long life and precision.

For unusually small or large Reali-Slim bearings for electronic applications, contact KAYDON of Muskegon.

GET THIS CATALOG!

24-pages of engineering and application data — specifications on size, seals, separators and design ideas. Ask for KAYDON engineering catalog No. 54.

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K549

PRECISION BALL AND ROLLER BEARINGS

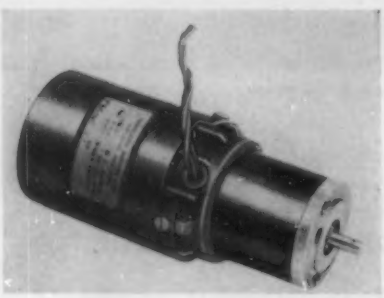
oz-in. at approximately 1650 rpm on 115 v, 60 cycle, continuous duty. The stray magnetic leakage field is low. Holtzer-Cabot Motor Div., National Pneumatic Co., Inc., 125 Amory St., Boston 19, Mass.

For more information—
Circle 33, inside back cover

Miniature Snap-Action Switch

A sub-miniature switch is housed in a glass fiber reinforced alkyd, which measures ¼ in. wide x 23/64 in. high x 25/32 in. long. These switches are furnished single-pole, double-throw, with one circuit normally open, the other normally closed, connection being made through silver-plated solder terminals at the bottom of the case. Mounting is by means of two No. 2 screws through the case. Switch rated 5 amp, 125 to 250 v, ac, 2½ amp, 30 v, dc. Milli-Switch Corp., 1742 Berkeley Street, Santa Monica, California.

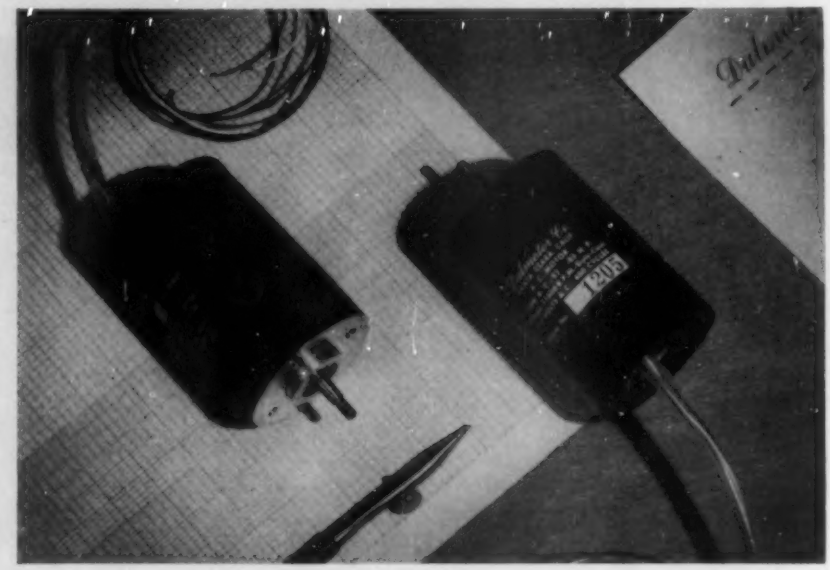
For more information—
Circle 34, inside back cover



Gear-Head Motors of 1/1000 to 1/10 Hp

The gear heads are available in a full range of ratios. The 1600 frame motors are available in induction or synchronous types, standard or self-cooled. They may be for 60 or 400 cycle or variable frequency (50 to 1600 cycles per sec) operation, single or polyphase. Either ball or sleeve- bearing construction is available and housing is aluminum. Induction Motors Corp., 570 Main St., Westbury, N. Y.

For more information—
Circle 35, inside back cover



Low-slip Induction Motor

Combining speed regulation with low slip, the AC-93 miniature sub-fractional induction motor was designed for tape recorder operation, servo or actuator motor, geophysical equipment uses. Although the standard unit is an induction motor, its design is such that it can be supplied with minor changes, as a synchronous unit with reduced power output.

Operating at 115 v, 400 cycles per sec., single-phase, the unit is rated at 11,800 rpm with a 15-w output. Locked rotor torque is 1.8 oz-in., min. Maximum power input is 45 w, and rotation is reversible. Weight is 14 oz. Dalmotor Co., 1362 Clay St., Santa Clara, Calif.

For more information—
Circle 36, inside back cover

Servo Amplifiers

The 434-B, 463-B and 472-B are complete 400-cycle servo amplifiers, requiring no auxiliary components such as demodulators, pre-amplifier, power supply and damping generators. Their significant feature is a null point stable from -55 C to 75 C, over power line variations of 100 to 130 v, and 360 to 440 cycles per sec. Size and weight have been reduced. They require six connections: two for input, two for output, and two for 117 v power. They are available in three different packages and mounting styles.

These amplifiers were originally designed for airborne automatic control. Industrial Control Company, Wyandanch, New York.

For more information—
Circle 37, inside back cover

Electrical Resistance-Type Pressure Pickups

High-pressure transients, too rapid for conventional transducers, are said to be easily measurable with two electrical resistance-type pressure pickups designed to measure gas and liquid pressures. The Type 4-313 is designed for general-purpose measurements and

CONTINUED ON PAGE 232

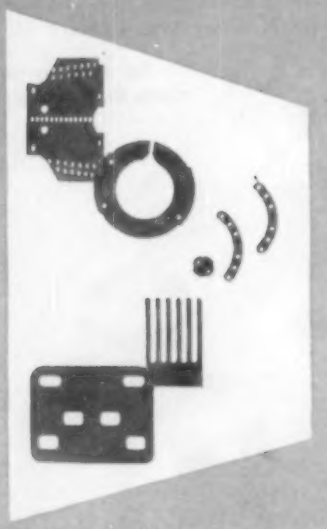
ONE OF THESE THREE

might be your answer to better insulation at lower cost

DUROID 800

PLAIN

Fibrous sheet material for use as replacement for paper-base laminates where moisture absorption is not a critical factor. Arc resistance, tensile and impact strengths of DUROID 800 are greater than XP paper-base laminates. Listed by Underwriters' Laboratories.



DUROID 800

COATED

Moisture pick-up almost as low as paper-base laminates; flexural strength much higher. Specific coatings — such as alkyds, epoxies and vinyls — can be applied to obtain characteristics available only in much more expensive materials.

DUROID 800

FLAME-RETARDANT

Retains more physical strength after exposure to flame. Self-extinguishing, with no afterglow. Easy to fabricate. Your tests may prove it satisfactory for applications now using much more expensive materials.

For technical data or samples of any of the above materials, please write Dept. E, Rogers Corporation, Rogers, Connecticut.

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Better Parts for Better Products

PRODUCTS

DUROIDS—for Gaskets, Filters, Electronic Devices, etc.
SHOE MATERIALS—for Counters, Midsoles, Liners, etc.
ELECTRICAL INSULATION—for Motors, Transformers, Generators, etc.
PLASTICS—Special Purpose Molding Compounds and Laminates

SERVICES

Research, Development, and Engineering of New Materials, Parts and Products • Fabricating, Combining, Coating, & Embossing

provides for flange-type mounting, while the Type 4-314 is supplied with a threaded case for hydraulic system applications where it is desirable to have the diaphragm flush with the liquid.

The pickups are available in 1000, 2000, 3000, and 5000 psi gage and absolute ranges, with other ranges available on special order. Each pickup weighs approximately 50 g. The Type 4-313 is 0.625 in dia, while the Type 4-314 is 0.75 in. Each pickup is a nominal 1 in. in length. Consolidated Engineering Corporation, 300 North Sierre Madre Villa, Pasadena 15, California.

For more information—
Circle 38, inside back cover

Gear-Driven Limit Switch

Limits of this switch can be adjusted by means of two slotted screws, and this can be done while equipment is in operation. There is no need for disengagement of gears. Positive protection is provided for unlimited over-travel. Available for use with current capacities up to 550v, the new switches are easily wired and installed. The hardened steel drive shaft operates on precision bushings. Gears are machined to close tolerance and only a minimum of lubrication is required. Clark Door Co., 515 Hunterdon St., Newark, N. J.

For more information—
Circle 39, inside back cover

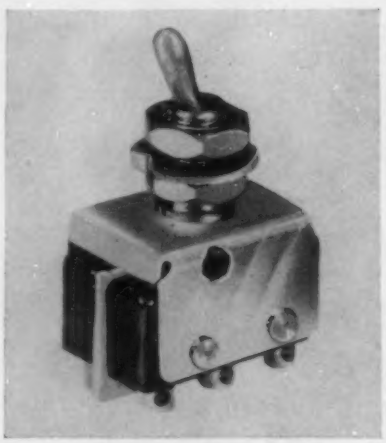
Permanent Magnet Generator With Servo Motor

Mounted coaxially with a standard two-phase servo motor, this motor-driven generator has an output with a voltage gradient which can be as high as 20 v per thousand rpm. The frequency of the output depends on the speed of the generator, which has a four-pole winding.

The servo motor can be operated from two-phase or single-phase supply and can be wound for 400 or 60 cycle applications. The motor torque available at the shaft end is on the order of 0.15 oz-in., depending on the power input, frequency and speed of the motor.

Dimensions of this motor and generator are 0.980 in. dia, 2$\frac{9}{16}$ in. long. Housing is stainless steel. Weight of the combination unit is 6.3 oz, max. G-M Laboratories, Inc., Dept. M, 4300 N. Knox Ave., Chicago 41, Ill.

For more information—
Circle 40, inside back cover



Miniature Toggle Switch

Two miniature basic switches, encased in the actuator, provide a double-pole, double-throw circuit arrangement. This switch is also available in a momentary contact model. Its shell is stainless steel; its spring mechanism is beryllium copper.

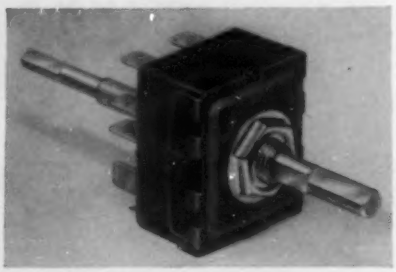
Switch is $\frac{7}{8}$ x $\frac{1}{2}$ in. Electrical rating is 125/250 v, ac, 5 amp; 30 v, dc, 4 amp resistive, 2.5 amp inductive. Electro-Snap Switch & Mfg. Co., 4218 W. Lake St., Chicago 24, Ill.

For more information—
Circle 41, inside back cover

Hermetically Sealed Coaxial Relay

A miniature, moving coil relay design has been developed that is mounted on a standard seven-pin tube base. It weighs 1$\frac{1}{2}$ oz. and is $1\frac{1}{8}$ in. dia. 1$\frac{9}{16}$ in. high. Marion Electrical Instrument Co., Manchester, N. H.

For more information—
Circle 42, inside back cover

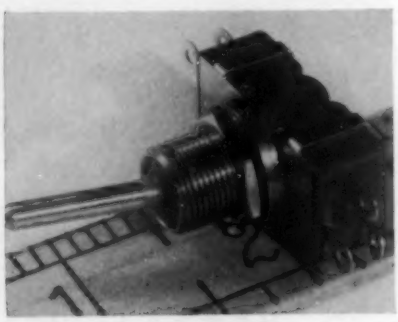


Rotary Switch Has Dual Coaxial Spindles

A series of small rotary switches with dual coaxial spindles provides simplified control of a second switch, a thermostat, solenoid, damper, valve or other electrical or mechanical unit. Carrying UL-approved ratings up to 20 amp, at 120 or 240 v, and $\frac{1}{2}$, $\frac{3}{4}$ and 1 hp at 120 v, and 2 hp at 240 v, ac; d-c ratings are also available. The outer shaft of the spindle controls the switch itself while the inner shaft, extending through the rear of the base, provides for independent operation of the auxiliary equipment.

Bases of the new switches measure only 1$\frac{1}{2}$ x 1$\frac{1}{4}$ x $\frac{7}{8}$ in. and have spade terminals for easy wiring. The switches are available single or double-pole, two to twelve positions, with stop as required and with single, two-hole or special mounting arrangements. Hart Mfg. Co., 110 Bartholonew Ave., Hartford, Conn.

For more information—
Circle 43, inside back cover



Panel-Sealed Toggle Switch

A miniature toggle switch, tested to more than 300,000 cycles, is said to reduce behind-panel space requirements by 50 per cent and can withstand acceleration, impact and

CONTINUED ON PAGE 234

PLASKON® Polyester Resins . . . first in the field

A smart tip for yachtsmen is the hull, molded of PLASKON Polyester Resins, reinforced with glass fibers. A reinforced plastic boat reduces maintenance because it is rot- and rust-free, corrosion-resistant, has exceptionally high impact strength and permanent color can be molded in to eliminate painting. Fifteen manufacturers have followed the tip and are now using PLASKON Polyester Resins in boats ranging from 8-foot dinghies to 36-foot cabin cruisers. And there's a tremendous variety of other products . . . car and truck bodies, aircraft parts, chairs and tables, luggage, and translucent panels for the home and office . . . that can be made *better* with the wonderful combination of polyester resins and fiber glass.

Your nearest Plaskon man represents an organization with years of leadership in the development of polyester resins. He knows your needs and problems, and how to answer them. Why not write him *today*?

Barrett PLASKON

For further information on PLASKON Plastics and Resins, address BARRETT DIVISION, Allied Chemical & Dye Corporation, 40 Rector Street, New York 6, N. Y. Phone HAnover 2-7300.

vibration to 200 F. The device has a switch-case 1.15 x 0.625 x 0.415 in.

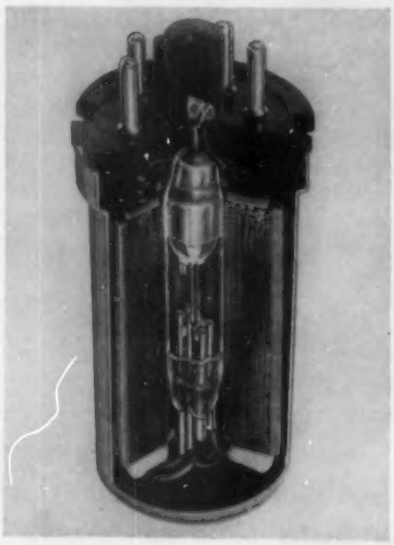
Contact rating is 10 amp at 125 v, ac; 10 amp at 30 v, dc; 1.5 amp at 125 v, dc. Opening force is 95 g, closing force 85 g. General Hermetic Sealing Corp., 99 E. Hawthorne Ave., Valley Stream, N. Y.

For more information—
Circle 44, inside back cover

Six-Pole, Double-Throw Sealed Relay

This unit withstands 0 to 2,000 cycle vibration to 30 G and withstands 60 G shock without contact opening. It is designed to exceed MIL-R-5757B and to meet MIL-R-25018 and MS-24115 specifications. It is available for both 85 and 125 C. Nominal coil voltage is 26.5 v, dc. Struthers-Dunn, Inc., Pitman, N. J.

For more information—
Circle 45, inside back cover



Mercury-Wetted Contact Relays

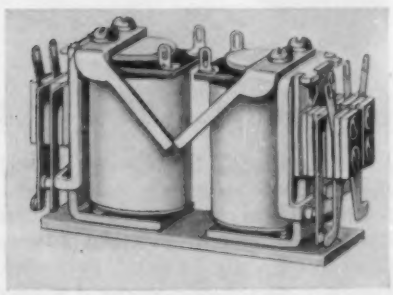
These relays, said to be capable of over a billion operations without maintenance, are designed for use in high-speed switching machines and devices. They will operate at up to 60 operations a second, have high current-carrying capacity (up to 5 amp), high voltage-handling capacity (up to 500 v), are bounce and chatter-free and keep a uniformity of operation to within 1.5 millisecond under constant drive conditions. C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45.

For more information—
Circle 46, inside back cover

Adjustable Return Spring Solenoid

Close settings are obtained by means of a vernier type adjustable spring anchor plate. Gear teeth stamped on the circumference of the anchor plate mesh with a small pinion gear. When the pinion gear is rotated with a small wrench (furnished) it drives the anchor plate and return spring to a precise adjustment. After the proper torsion on the return spring is obtained, the setting is locked by tightening the lock screw against the anchor plate. G. H. Leland, Incorporated, 123 Webster Street, Dayton 3, Ohio.

For more information—
Circle 47, inside back cover

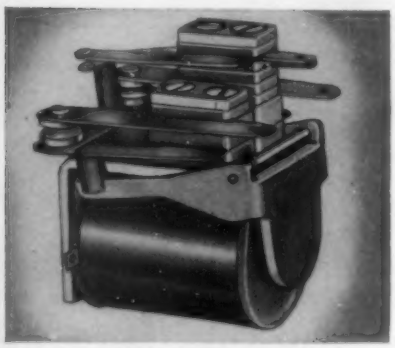


Miniature Latch-in Relay

A miniature latch-in relay in which the armature mechanically latches in the energized position is comprised of an operating relay and a reset relay with mechanically interlocking arms. When the operating coil pulls the armature into the energized position the levers mechanically lock the armature in place. The armature may be reset electrically or manually.

The latching levers are alloy steel, heat-treated and hard chrome-plated. Available for 6, 12, 24, 48 and 115 v, d-c operation. Approximate overall length, 2⅜ in.; width, 1 in.; height, 1⅝ in. Magnacraft Electric Co., 3350Y W. Grand Ave., Chicago 51.

For more information—
Circle 48, inside back cover



Midget 15 Amp Relay

This telephone-type unit is capable of withstanding an inrush current of 50 amp at 28 v, dc, and is rated for continuous operation at 15 amp, 28 v, dc. Standard 3-amp auxiliary contacts can also be supplied. Approximately 1¼ in. long, the unit weighs 2½ oz. Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago 12, Ill.

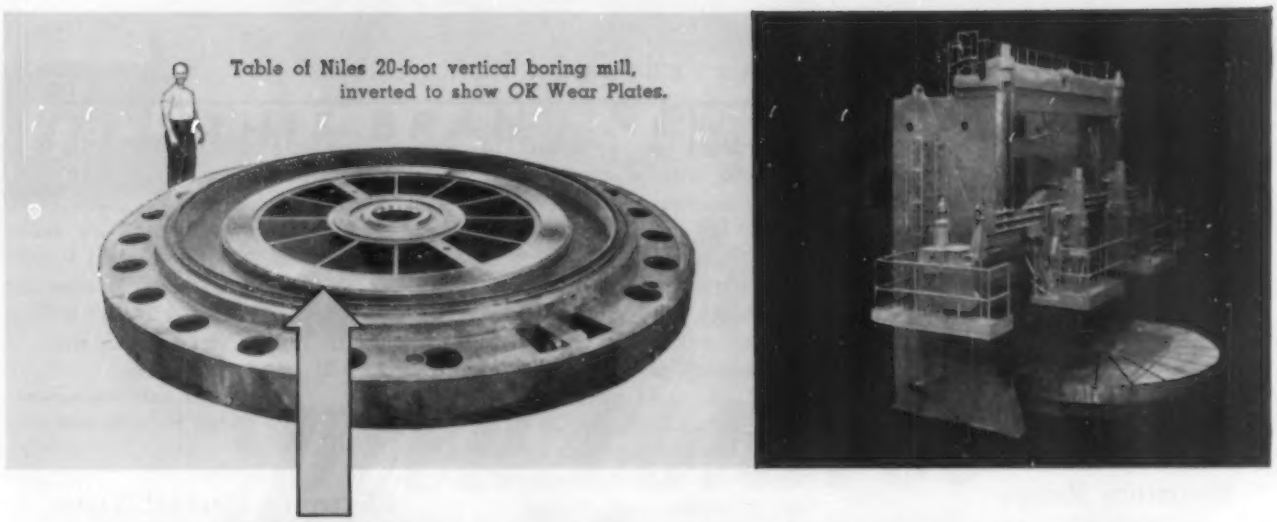
For more information—
Circle 49, inside back cover

Relay With 10 Milliwatt Per Contact

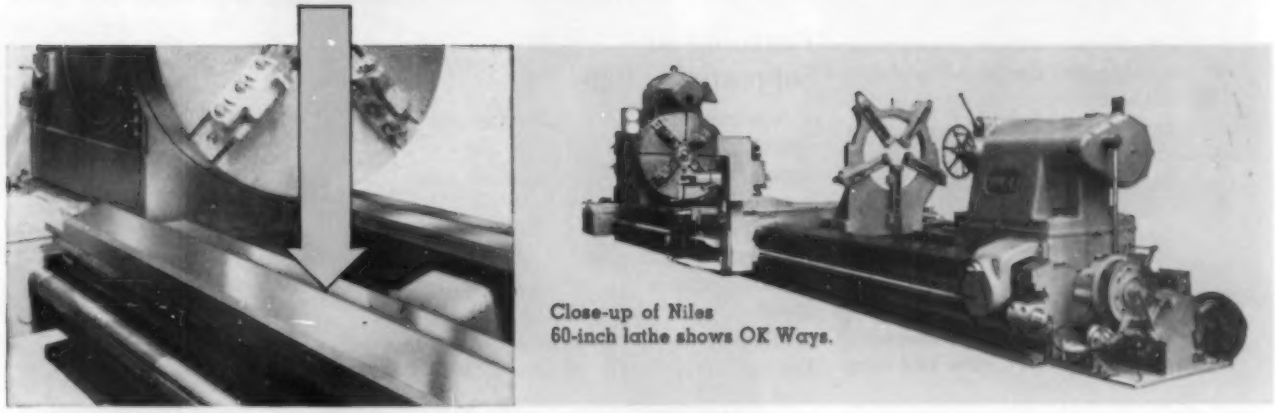
Engineered for d-c applications, this relay is available either hermetically sealed or with dust cover in contact combinations from single-pole, single-throw to double-pole, double-throw. Coil resistance up to 30,000 ohm is available and contact capacity up to 1 amp inductive and 3 amp resistive load.

Non-ferrous metals and hydrogen

CONTINUED ON PAGE 236



good ways to keep customers happy



THE NILES TOOL WORKS . . . of the Baldwin-Lima-Hamilton Corp., is one of many U. S. machine tool builders using OK Hardened Ways and Wear Plates. Their mammoth machine tools require ways and wear plates that maintain absolute accuracy for the life of the machine. OK Ways and Wear Plates are used because our unique manufacturing and hardening processes make them virtually wear-proof.

Special-analysis tool steel is welded to a soft steel backing, resulting in a work surface of high wear-resistant properties. This process permits manufacture in long lengths without danger of bowing or warping.

Hardening is done in electronically-controlled furnaces, giving a ROCKWELL C 64-66 the full depth (normally 3/16") of the tool steel. They are precision ground to tolerances of ± .0002" with low micro-inch finish.

Make your customers happy. Insure trouble-free operation of your machines with OK Ways and Wear Plates (also available in clad aluminum bronze). Our engineering staff will assist you in your design or production problems.

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Wear Strips
Bronze Ways

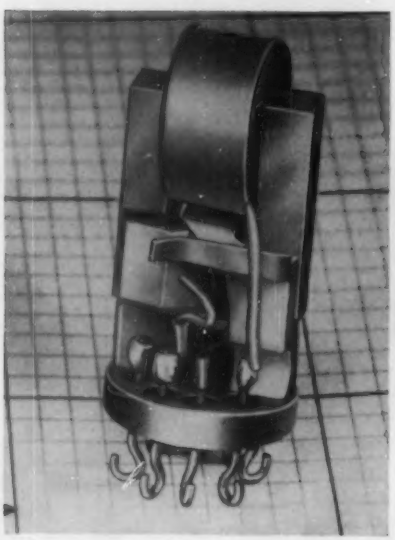
annealing of magnetic components are said to eliminate iron-aging and residual magnetism. Armature is securely locked without hinge pins. Dimensions are 1¼ x 3⅜ in. Hedin Tele-Technical Corp., 640 W. Mt. Pleasant Ave., Livingston, N. J.

For more information—
Circle 50, inside back cover

Inert Gas-filled, Miniature Relays

Type DC-34 is a miniature four-pole, double-throw hermetically sealed relay designed to perform under severe service conditions. It will function without contact chatter, energized or non-energized, during vibration of 30G to 500 cycles per sec, 15G to 2000 cycles per sec and shock of over 100G. Contacts are pure silver and rated at 2 amp resistive load at 28v, dc, or 115 v, ac, with minimum life of 100,000 operations. Deltronic Corp., 1507 Riverside Dr., Los Angeles 31, Calif.

For more information—
Circle 51, inside back cover



Miniature Two-Pole Relay

Maximum space conservation in a relay of high-performance characteristics is asserted to be achieved in a new sub-miniature, two-pole design. Less than 1½-in. high, the new relay is enclosed in a cylindrical can equipped with a conventional two-hole mounting flange 1$\frac{3}{32}$ x ¾ in. Weight is 1 oz, max.

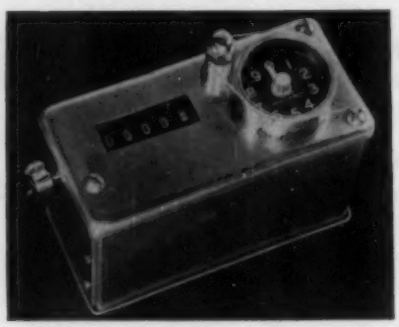
The new HG-2SM relay withstands shock accelerations in excess of 80 G at frequencies up to 2000 cycles per sec. with no contact break. It is capable of operating at temperatures up to 200 C. Contact current in the new relay is rated at 3 amp, 28 v, dc, and 3 amp, 115 v, ac, with contact life in excess of 100,000 operations. Hi-G Inc., Windsor Locks, Conn.

For more information—
Circle 52, inside back cover

Fastening and Supporting Straps

Non-corrosive plastic straps for fastening and supporting all types of open wires, cables and cords are being made of polyethylene. They are made in black and ivory colors. The edges of the straps are thick, pliable and round for protection against short circuits, especially under conditions of vibration, strain, wind and weather. The mounting holes are designed to hold screws or nails while driving. Holub Industries, Inc., Sycamore, Ill.

For more information—
Circle 53, inside back cover



Electrically Driven Pulse Counter

This counter uses a special six-figure register driven by a stepping motor, started and stopped magnetically each half cycle. The motor has but one moving part which makes contact only with the ball bearings on which it rotates.

Counting rate is said to be 0 to 130 count per sec, at an accuracy of ± ½ count. Either d-c pulses down to 3 millisecond wide or a-c cycles with a minimum half cycle of 3 millisecond may be counted. Service life is conservatively rated at 500 million counts. Sigma Instruments, Inc., 77 Pearl St., Boston 85, Mass.

For more information—
Circle 54, inside back cover

Electronic Interval Timer

Normal 60-cycle current is converted to 120 cycles per sec and each impulse is registered by this timer. Timed operations, in seconds, are automatically controlled.

There are two rows of selector switches and a dual timing circuit is possible. Four models are offered. Post Machinery Co., Beverly 11, Mass.

For more information—
Circle 55, inside back cover

High Speed Electronic Counter

Having printed circuits and a miniature high-speed mechanical register combined with one electronic decade, the Model 345 counter is capable of a sustained rate of 200 counts per sec. Trigger level is 2.5 v, positive, and is independent of pulse wave form or rise time. Pulses may originate from contact closure or from plug-in photoelectric or magnetic pick-ups.

Count capacity is 1 million. Reset is instantaneous. Pulse pair resolution is 5 microsecond. Input impedance

CONTINUED ON PAGE 238

Free! THIS BRAND NEW BOOKLET ABOUT

automatic speed control

HOW TO APPLY THE ADVANTAGES OF VARIABLE SPEED TO AUTOMATION

Typical applications of Varitrol pneumatic control regulating the speed of Varidrives in response to a signal from such variables as temperature, humidity, pressure, speed, liquid level, weight and tension are dramatically pictured and explained in this full-color booklet. How the Varitrol pneumatic system functions is illustrated with full-color cross-section drawings and diaphanous views of the U. S. Varidrive with exclusive right angle speed-changing linkage. This educational booklet, edited by variable speed engineers, is your guide to a method of greater production of more goods and services at lower cost and astounding man-hour savings. Write today for your complimentary copy.

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is one megohm. Weight is 7 lb. Daytronic Corp., 216 S. Main St., Dayton 2, Ohio.

For more information—
Circle 56, inside back cover

Electrical Read-out Counter

A high-speed pulse-actuated electromagnetic counter both adds and subtracts, using separate coils. C-20-5 series have connected to each of 5 counter wheels a ½ w potentiometer which indicates the visual number by a proportional voltage. C-30 series have ten electrical contacts corresponding to the numbers on each wheel. Operates up to 40 counts per sec on dc. Available for ac, with built-in rectifier. Power requirement 10 w, continuously rated. Size 2 x 3 x 4 in. in hermetically sealed case. Nemeth, Inc., 2223 S. Carmeline Ave., Los Angeles 44, Calif.

For more information—
Circle 57, inside back cover

Electric Counters

These counters are said to have an average life expectancy of 300 million counts. Rated at 1000 counts per minute, the new counters actually operate at speeds up to 1600 counts per minute when suitably actuated.

Current draw of less than 5 w permits dependable operation in the plate circuit of electronic tubes having an output of 5 w or more. Balanced armatures are asserted to avoid error ordinarily caused by shock or vibration.

For a-c or d-c current to 230 v in four- and six-digit models with knob or key reset. Production Instrument Co., 702-10 W. Jackson Blvd., Chicago 6, Ill.

For more information—
Circle 58, inside back cover

Finger-Type Regulator

This direct-acting regulator has a medium finger using an improved silver contact. The width and thickness of the finger has also been increased to improve current-carrying characteristics. Electric Regulator Corp., Pearl St., Norwalk, Conn.

For more information—
Circle 59, inside back cover

Electric Counting Device

A counting device has recently been announced that is said to contain a one-piece, cog-action actuator which insures positive stepping for each impulse up to 300 counts per min. The new counter is of the non-reset type, with cadmium-plated case.

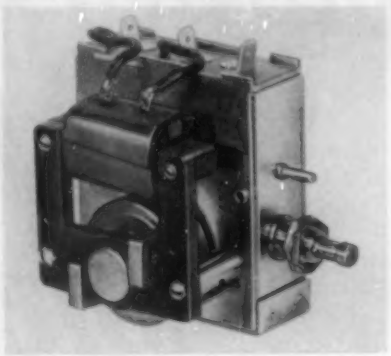
The four-digit model is 1⅞ in. wide, 1⅜ in. deep, 2⅜ in. high. Weight is approximately 6 oz. Standard counters are available for 50 and 100 v. Como Manufacturing Corp., 5013 N. Kedzie Ave., Chicago 25, Ill.

For more information—
Circle 60, inside back cover

Pushbutton Electrical Timer

This timer has a heavy duty switch, solderless snap-on terminals for easy installation and completely enclosed switch and gear mechanisms. It has an accurate, fixed (non-adjustable) timing period. A wide range of timing periods, from 20 sec to 24 hr, is available.

The 110 series timer is equipped with a synchronous motor, for a-c current, 110 or 220 v, 25, 50 or 60 cycle, 30 amp rating. Dimensions are



2½ x 1$\frac{13}{16}$ x 3$\frac{5}{32}$ in. Miller-Harris Instrument Co., 601 E. Ogden Ave., Milwaukee 2, Wis.

For more information—
Circle 61, inside back cover

Counting Device That Also Subtracts

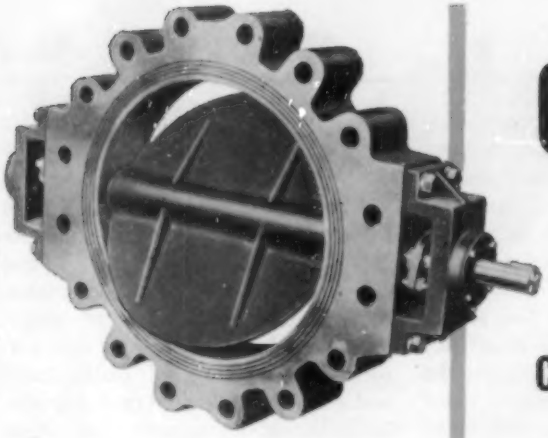
This counter will count or subtract at a rate of 400 counts per min, up or down, in any sequence, one count per impulse, maximum 999. It can be set at a predetermined figure to automatically shut off at zero and measures 6½ in. wide, 3½ in. deep, 6½ in. high. Weight is 2 lb, 5 oz. Electrical coils are intermittent duty, 6 v to 110 v, ac. It can be actuated by photoelectric cell, tube, relay or contact switch. Spencer Mfg. Co., 3253 N. Cicero Ave., Chicago 41, Ill.

For more information—
Circle 62, inside back cover

Plug-In Terminal Block

These high-current blocks are reported to provide high-pressure solderless anchoring of each individual con-

CONTINUED ON PAGE 240



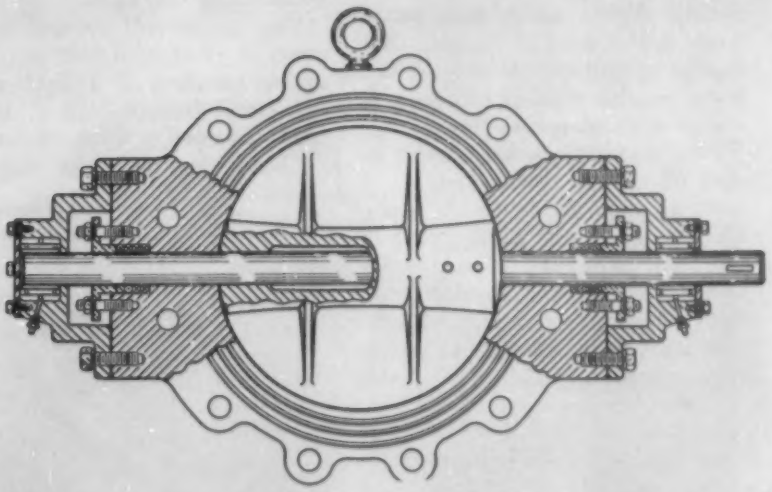
ORANGE ROLLER BUSHINGS

assure smooth, friction-free operation of Thru Shafts in

CONTINENTAL BUTTERFLY CONTROL VALVES

"15 years of Satisfactory Service" reports Continental Equipment Company, Coraopolis, Pa.

Continental Butterfly Valves, in sizes from 2" to 96" dia., are used for manual or automatic control of all types of fluids. An important feature is the continuous, one-piece shaft through valve body and disc to provide maximum disc support—maximum rigidity—and true alignment that eliminates binding. Compact, high-load Orange Roller Bushings at each end of the shaft help to maintain these operating features.



Stop friction and wear on rotating or oscillating shafts, pins and parts by installing Orange Roller Bushings. Exceptionally high load capacity in very small space permits more compact designs — provides smoother, quieter running — eliminates troubles and complaints in the field.

Many construction features of Orange Roller Bushings include electronic gauging of rollers for controlled uniformity; closer internal running clearances to minimize misalignment of rollers; finest bearing steel; all raceways through-ground; highest standards of heat-treating, finishing and inspection.

Specify Orange Roller Bushings wherever designs call for needle bearings. Consult our engineers on any application.

Available in stock sizes from ½" to 8" shaft dia., fully interchangeable with all standard heavy-duty needle bearings. Stocked and serviced in all principal industrial areas.

ORANGE
ROLLER BUSHINGS

Write for Engineering Data Book

ORANGE ROLLER BEARING CO., Inc.
551 Main Street
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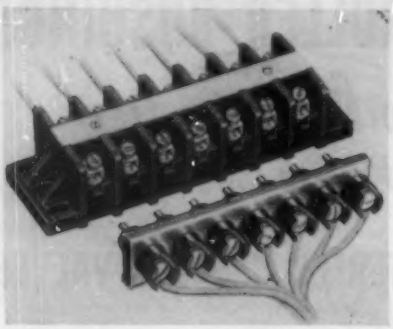


nector for a positive low-resistance contact. White marker strips permit quick identification of circuits. Any number of multiple contacts are said to be possible without high cost or a large stock of special plugs.

This block may be had, factory assembled, in any specific number of terminals from one to 16. It is possible to mount the blocks, or male conectors, adjacent or side-by-side where a connect-and-disconnect feature is required on terminal blocks with more than 16 terminals. It has ample clearance and leakage distances for use in circuits carrying up to 300v, 20 amp. Curtis Development & Mfg. Co., 3266 N. 33 St., Milwaukee 16.

For more information—
Circle 63, inside back cover

Panel-Mount Frequency Meters

These 3½ in. instruments are direct-reading frequency meters based on the well-known and time-tested principle of resonance. They consist of a number of steel reeds which are tuned to specific frequencies. They come with 5, 7, 9, 11, 21, 36 or 41 reeds for normal frequencies of 25, 50, 60 and 400 cycle. Other ranges from 15-1500 cycle per sec can be supplied. Accuracy of calibration is 0.5 per cent. Herman H. Sticht Co., Inc., 27 Park Pl., New York 7, N. Y.

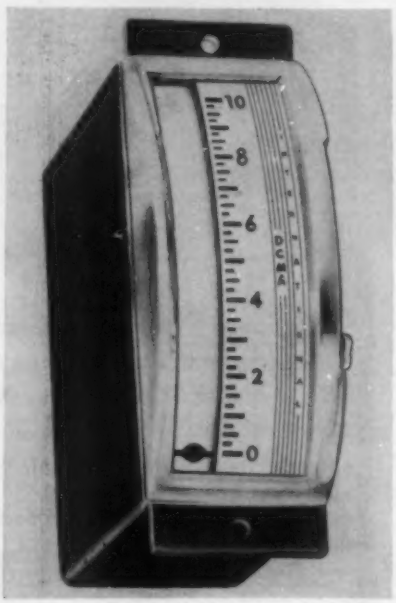
For more information—
Circle 64, inside back cover

Registration Control

A registration control which operates continuously over both high and low speed ranges without special attachments was designed for maintaining accuracy in automatic machine operation on paper, textiles, plastics, tin, steel or other sheet material. This control responds instantly to the appearance of a mark printed on material moving past at speeds from 15 to more than 500 fpm. The abrupt change in light intensity caused by the passage of this mark actuates the control relay which will trigger speed correction devices, keeping the material in perfect synchronization with the machine operation.

The circuit will respond to impulses as short as 0.0005 sec. The scanner consists of a light source, lens system, phototube and amplifier tube. Electronics Corp. of America, 77 Broadway, Cambridge 42, Mass.

For more information—
Circle 65, inside back cover



Vertical or Horizontal Meters

Developed primarily to save space and improve readability for complex electronic equipment and in large electrical control panels, the Model 1145 meters are available for vertical or horizontal mounting, and require a panel area of only 5.5 sq. in. as compared to 16.4 sq. in. for a conventional 4½ in. round instrument and 18.6 sq. in. for a 4½-in. rectangular meter. Overall dimensions are 3.5 in. wide, 1.3 in. high, 3.5 in. deep (plus terminal length as required).

These indicators are described as having an initial accuracy of ±2 per cent of full scale deflection on dc and ±5 per cent on ac. Micrometer, milliammeter, and ammeter ranges are available. All meters are self-contained in dustproof plastic cases and provide an external zero adjuster. International Instruments Inc., New Haven 15, Conn.

For more information—
Circle 66, inside back cover

Panel Instruments

A line of core-magnet, self-shielded panel instruments in the 3½ in. size is available for d-c or as a-c rectifier-type instruments in both round and rectangular shapes. The mechanism employed automatically affords shielding from external magnetic fields, eliminating inter-effect when instruments are mounted close together. They also can be mounted on magnetic or nonmagnetic panels interchangeably without need for special adjustment. Basic accuracy for these instruments is within ±2 per cent of full scale range; and ±3 per cent for the a-c rectifier types. Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

For more information—
Circle 67, inside back cover

Sight Flow Indicators

These indicators, for viewing liquid flow, can be installed in any new or existing pipe line ½ to 2 in. pipe size. They are available in transparent two-window and one-window, and reflex one-window types.

Visibility is improved by turbulence, caused by the interrupted bore of the fitting. Several types of indicating vanes may also be furnished, according to variable conditions of rate of flow and viscosity of liquid. These are installed within the chamber and show the flow or absence of flow by movement when liquid is flowing.

In addition to the standard carbon

CONTINUED ON PAGE 242

Bright ideas..

The automotive industry is noted for its Bright Ideas . . . it uses felt in at least 82 different ways, because the right type of felt does those jobs best.

It's a Bright Idea to keep felt always in mind, for factory processes and equipment, and for finished products of all kinds. No matter what you make, or are designing, remember that felt can polish, seal, lubricate, control vibration and noise, act as a filter, do many other tasks with efficiency, economy and long life. American supplies felt of all types, in rolls, sheets, and parts cut to your dimensions, ready for assembly. If you will tell us what you make, we will consult with you and provide technical information.

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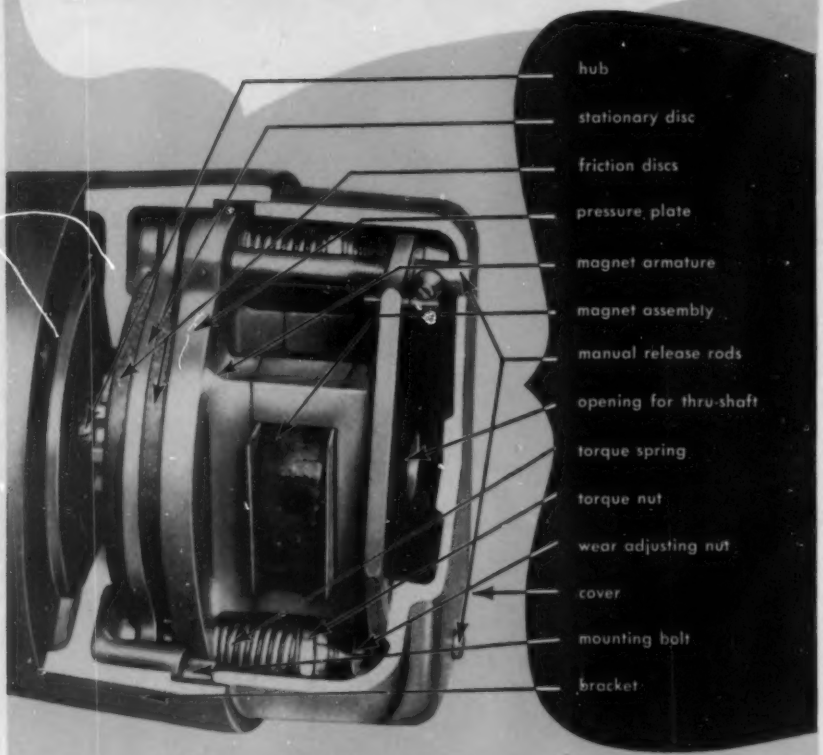
here are important reasons for
specifying **DINGS *Direct Acting***
MAGNETIC DISC BRAKES!



✻ Backed by years of specialized experience, the new Dings DIRECT-ACTING Magnetic Disc Brake now offers a combination of design and operating features never before offered to industries where automatic, controlled braking is required.

With simple, rugged construction, the new Dings Brakes are fully accessible, simple to install and adjust . . . with full direct action, which eliminates all mechanical linkages and levers, assuring instantaneous release and consistent, positive stops.

The new Dings Brake accommodates the standard NEMA shaft extension, and may be used for THRU-SHAFT when specified. Designed to meet new re-rated and old NEMA motor standards. Torque ratings from 1½ through 175 lbs. ft.

Write for new Bulletin BK 4002

DINGS BRAKES, INC.
A SUBSIDIARY OF DINGS MAGNETIC SEPARATOR CO.
4715 West Electric Avenue
Milwaukee 46, Wisconsin

DB255-2/3

See our Catalog in SWEETS PRODUCT DESIGN FILE—Section 5a/Di.

steel model, these sight flow indicators are available in a wide variety of special stainless steels and other metals, as well as with linings of lead, phenol and rubber. Pressure-temperature ratings vary from 2000 psi at 100 F to 600 psi at 1000 F, in transparent double window types, and up to 3000 psi at 100 F or 1000 psi at 1000 F in the single window or reflex window types. Jerguson Gage & Valve Co., 80 Fellsway, Somerville, Mass.

For more information—
Circle 68, inside back cover

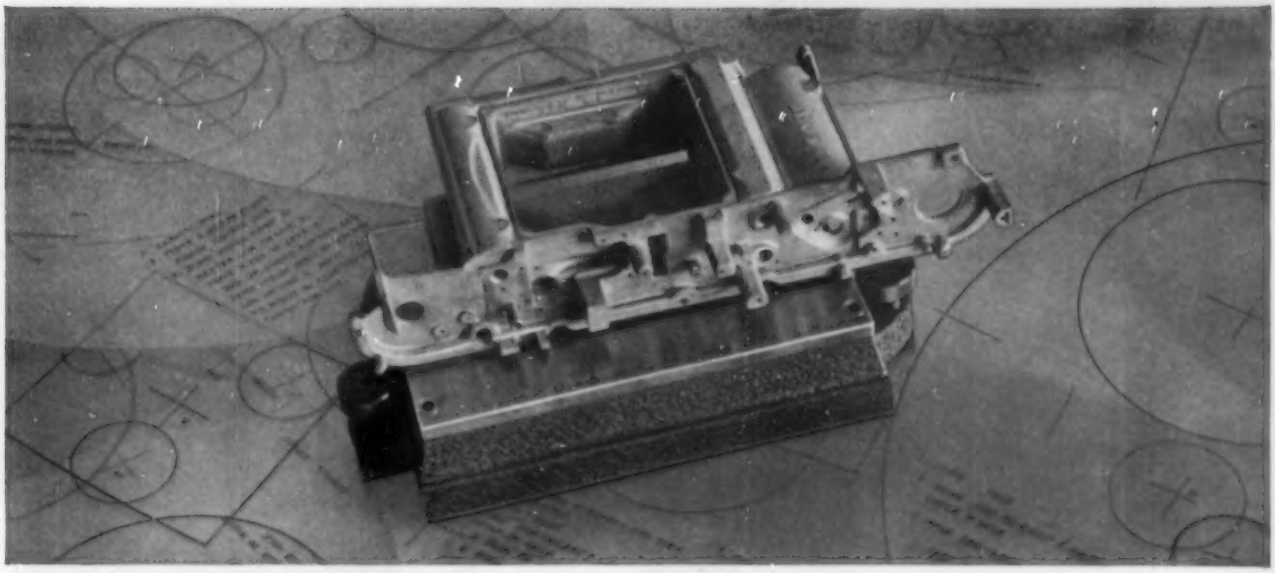
Automatic Digital Controller

Heart of this controller is a unit 7 in. high, 10 in. wide and 8 in. deep which adds and subtracts automatically at rates up to 20 decimal digits per sec with an accuracy of 0.04 per cent. Two 50-position stepping switches are so connected as to permit 50 x 50 or a maximum of 2500 counts. Counts come into the stepping switches from any pulsing device used as a transmitter. This could be a mechanical switch, or photocell, transducer or thermocouple. American Electronic Mfg., Inc., 9503 W. Jefferson Blvd., Culver City, Calif.

For more information—
Circle 69, inside back cover

Resistance Thermometer Elements

Glass-protected, platinum-wound resistance spirals used for temperature measurement over the range of −200 C to 550 C have a guaranteed accuracy of ± 1 C. Accessory equipment such as wells, heads can be ordered for 60-day delivery. A high temperature resistance element encased in an appropriate ceramic en-



How Graflex, Inc., *cut production costs* with a Kodak Contour Projector

If you've been thinking of optical gaging only in terms of toolroom measurement or final inspection, see what it does when linked to production operations.

GRAFLEX, INC., was producing a complex precision part in which spacing of 40 holes and 12 bosses had to be held to ±.001".

To solve this tolerance problem, Graflex used a Kodak Contour Projector because: (1) mechanical gages would have been too costly for the required run; (2) optical gaging would be faster; (3) the Kodak Contour Projector gave a quantitative as well as qualitative check.

Here's how this helped cut production costs and speed the work:

Optical gaging made it possible to check parts as they were run, to discover errors before more time and labor were spent on the part; no expensive machining was wasted on parts later found to be out of tolerance. It assisted in assembly operations, too, since the exact condition of the parts was known. And the part could be quickly rechecked at any point during production when a question of tolerance or condition arose.

A Kodak Contour Projector was also used in final inspection—doing in 20 minutes a job estimated at 4¾ hours by surface plate inspection. When the run was completed, the comparator was available for another job.

Perhaps you have production problems that can be solved by fast, accurate, *complete* measurement and inspection. There's a field representative in your area who can evaluate your needs for you. To get in touch with him, or for a copy of the illustrated booklet "Kodak Contour Projectors," mail the coupon below.

Graflex, Inc., used a Kodak Contour Projector, Model 2A, for this operation. The Model 2A is completely equipped for precision micrometry. In addition, it has a magnification selector, built-in surface illuminator, and permits the staging of parts in any plane. As with all Kodak Contour Projectors, it requires no hood.

the KODAK CONTOUR PROJECTOR

15

EASTMAN KODAK COMPANY
Special Products Sales Division, Rochester 4, N. Y.

☐ Please send me a copy of your booklet "The Kodak Contour Projectors."
☐ Put me in touch with your representative.

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CITY_____ STATE_____
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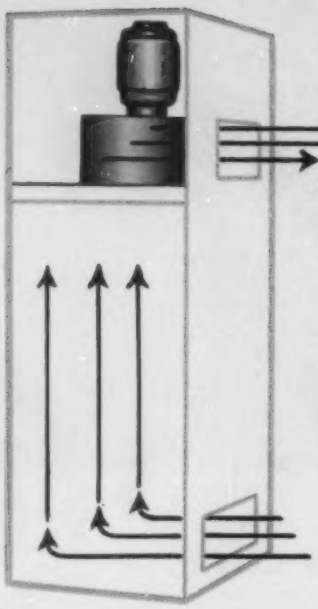

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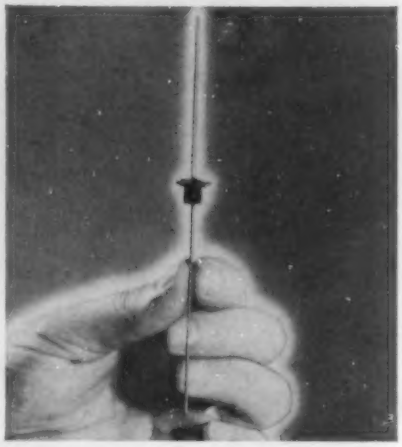
velope is available for measuring temperatures up to 750 C. Charles Engelhard, Inc., 850 Passaic Ave., E. Newark, N. J.

For more information—
Circle 70, inside back cover



Silicon Power Rectifiers

High-current, high-voltage silicon power rectifiers said to have an efficiency of approximately 99 per cent, were designed to operate in ambient temperatures of 100 C and higher. Occupying about $\frac{1}{8}$ cu. in. and weighing about 0.1 oz, these rectifiers are hermetically sealed.

Many types and sizes of this silicon power rectifier are already in production. They are rated from 100 to 500 milliamperes. The maximum forward drop at full rating is less than 2 v, with blocking voltages from 50 to 500 v in the standard ratings, and up to 1000 v on special applications. Specialized types with higher current ratings are available in pilot run quantities. Bogue Electric Mfg. Co., Paterson, N. J.

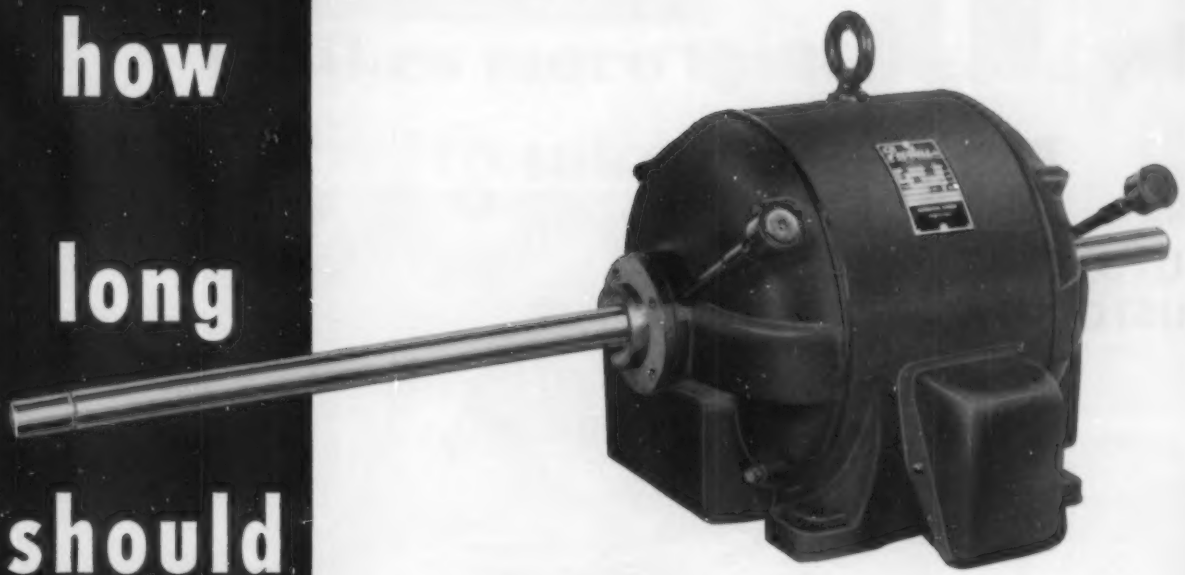
For more information—
Circle 71, inside back cover

Wire-Wound Trimmer Potentiometer

A $\frac{3}{4}$ in. dia potentiometer is now available in standard values of 25, 500, 1000, 5000, 10,000, 50,000, 100,000 ohm. A 5 per cent resistance tolerance is standard with a temperature coefficient of 0.00002 and a resolution of 0.1 per cent available in the higher resistance values.

The case is made of aluminum, terminals are gold-plated, contacts are

how long should a shaft be ?



● This unique motor was designed by Peerless engineers to drive a siren. The motor has a rather long acceleration period and is fitted with special grease cups that protrude beyond the siren housing. The shaft is unusually long—37″ and must be exceptionally true from end to end. This is one of hundreds of motors produced by Peerless "teamwork-engineering"—our engineers working with customer engineers to create the one motor that does the job best. Peerless can design similar features for you. Let us work with you on your next motor application. A letter or phone call will get us started.

Rice Leaders of the World Association

ELECTRIC MOTOR DIVISION

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WITH Bijur Automatic Lubrication as an integral part of your equipment, your customers benefit from continuous peak production. Plant after plant reports increased out-put and greatly reduced maintenance costs with Bijur-equipped machines. Costly downtime for lubricating by hand is eliminated. Every bearing is metered the proper quantity of oil at predetermined intervals. Work spoilage and bearing troubles caused by over-lubrication are avoided. Fire hazards are reduced. Personnel accidents are prevented.

Bijur gives you the opportunity to add customer satisfaction through improved machine performance.

More than a million Bijur-protected machines are in use. Hundreds of leading manufacturers standardize on Bijur as "built-in" components of their machines. Bijur emphasizes custom-engineering, and we will gladly cooperate in designing a system to meet the specific requirements of your machine.

Design Bijur into your machines now in production or in the planning stage. Write for literature and engineering information.

2249

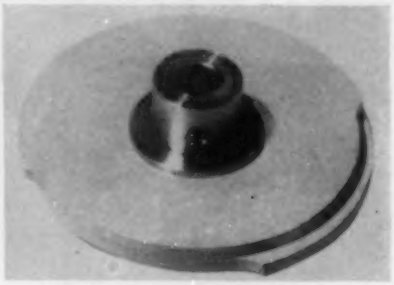
BIJUR LUBRICATING CORPORATION

Rochelle Park, New Jersey

Pioneers in Automatic Lubrication

of precious metals and the shaft and locating pins are of type 303 stainless steel. The new potentiometer is designed to operate at a temperature range of −55C to 125 C with a dielectric breakdown exceeding 1000 v, rms, at 25 C. Maurey Instrument Co., Dept. M-24, 2450 E. 72 St., Chicago 49, Ill.

For more information—
Circle 72, inside back cover



Adjustable Cam Assembly

This cam assembly is designed to be used where physical displacement of any microswitch or similar actuating device is required. The two stainless steel cams can be rotated with respect to each other and locked at any desired timing position.

The stainless steel shaft adaptors are designed for three basic shaft sizes: $\frac{1}{8}$, $\frac{3}{16}$ and $\frac{1}{4}$ in. They have stainless steel setscrews for holding and sub-drill holes for fixed pinning, as desired. Pic Design Corp., 160 Atlantic Ave., Lynbrook, N. Y.

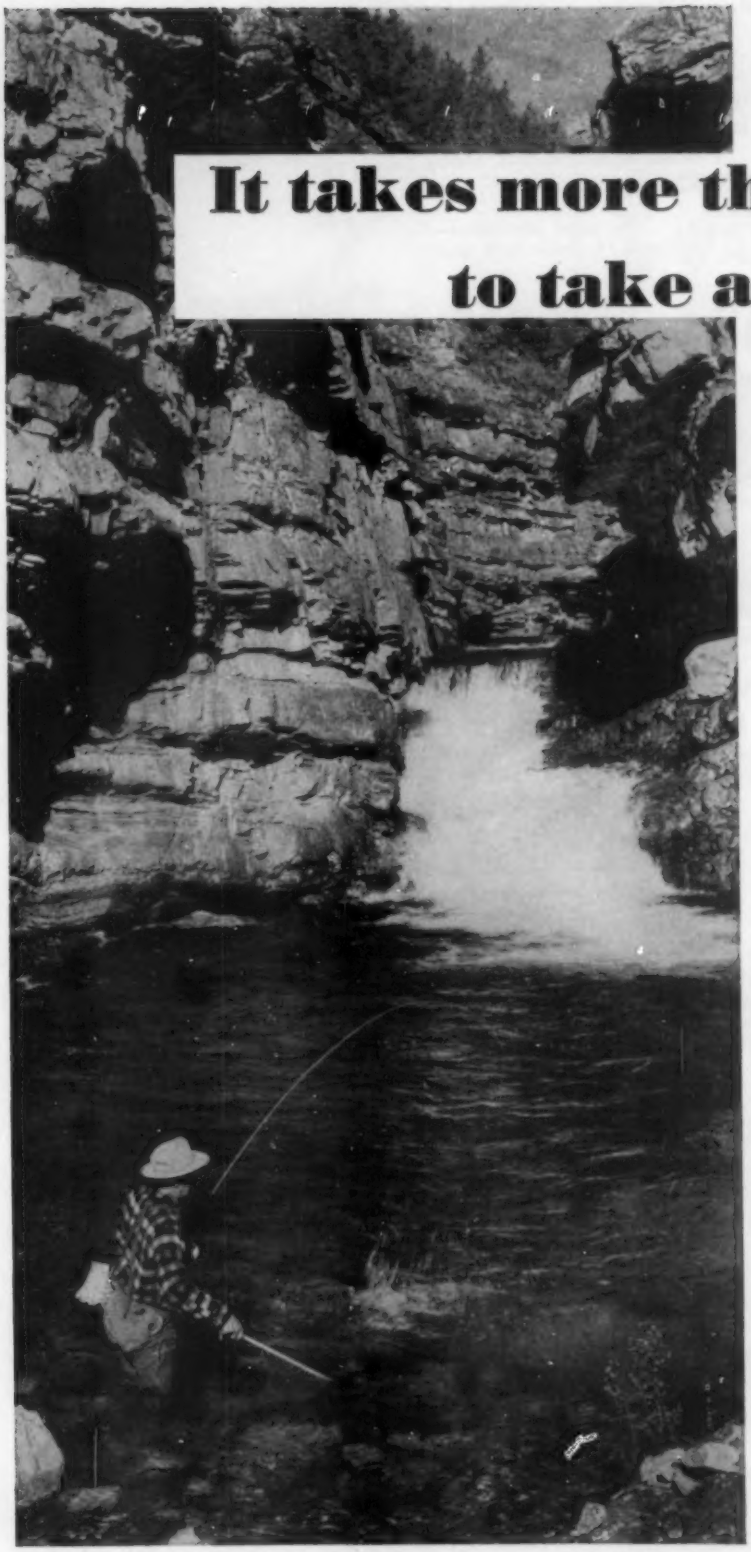
For more information—
Circle 73, inside back cover

High Resolution Potentiometer

This potentiometer consists of a high resolution, single-turn potentiometer which actuates a ten-position attenuator switch as the potentiometer reaches the end of its travel in either direction. This switch transfers the potentiometer to any one of the ten voltage positions provided on the ten-step attenuator switch.

The unit is reportedly able to replace a pair of controls where both coarse and fine adjustment steps are desired. The high resolution of the unit makes it ideal for a zero-adjust control or a precision gain control.

The assembly is $1\frac{3}{4}$ in. dia., $1\frac{3}{4}$ in.



It takes more than a good fly to take a trout

Even the costliest fishing gear, the finest rod, the best reel and the prettiest fly can't assure catching a wily trout. It's the experience behind these accessories, that fills the creel.

There's no substitute for "Know-How" and that's particularly true in adapting metal treating chemicals to established production. It can't be gotten out of books, through black magic or out of a crystal ball. Only years of active contact, with actual manufacturing procedures, can be depended upon for satisfactory solutions of the metal protecting problems constantly confronting manufacturers.

ACP offers ideal products for removing and preventing rust on metal, chemicals to bond paint to steel, zinc, and aluminum, and pickling acid inhibitors. In addition, ACP furnishes a free service of an organization of technical experts with over 40 years' experience in solving metal preservation problems for the largest as well as the smallest operation.

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CHEMICALS ACP PROCESSES

AMBLER, PENNA.

DETROIT, MICH. NILES, CALIF. WINDSOR, ONT.

long (behind the panel) and mounts in a single $\frac{7}{8}$-in. panel hole. A standard $\frac{1}{4}$ in. dia operating shaft is provided. Electro Measurements, Inc., 4312 S. E. Stark St., Portland 15, Ore.

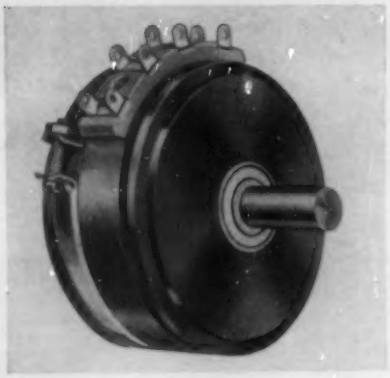
For more information—
Circle 74, inside back cover

Miniature Ten-Turn Potentiometer

This potentiometer has a linearity of 0.05 per cent standard and 0.025 per cent as a special tolerance where required. Overall length is $1\frac{3}{8}$ in. from front mounting surface. Diameter is $\frac{3}{4}$ in. The red anodized aluminum housing is fully shielded.

Resistance range is 1000 to 100,000 ohm, with a tolerance of ±5 per cent. Ambient temperature range is −55 C to 125 C. Power rating is 5 watt 40 C, derated to zero at 130 C. Maximum starting torque is 0.75 oz-in. at 20 C and running torque 0.60 oz-in. Technology Instrument Corp., 531 Main St., Acton, Mass.

For more information—
Circle 75, inside back cover

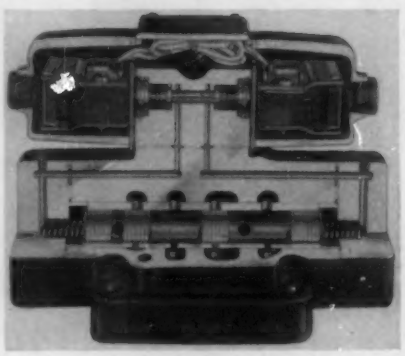


Potentiometer for Non-Linear Requirements

As many as 25 of these units may be ganged on a common shaft during manufacture, while 13 tap connections can be added to each pot. Every tap is spot-welded to a single turn of resistance wire. Dimensions are $1\frac{3}{4}$ in. dia, 0.8 in. long, with a $\frac{1}{4}$ in. shaft. Range is −55 C to 90 C. Rating is above 5 w at 25 C, above 4 w at 40 C, and 2.5 w as high as 60 C. Helipot Corp., 916 Meridian Ave., S. Pasadena, Calif.

For more information—
Circle 76, inside back cover

HYDRAULICS AND PNEUMATICS



Four-way Hydraulic Valve

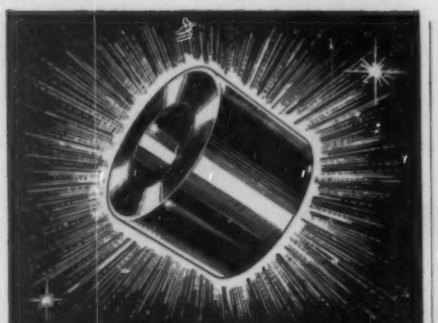
A $\frac{3}{4}$-in., balanced piston, sleeve-type, 2000 psi, four-way valve is solenoid-controlled, pilot-operated, and subplatemounted. Solenoids are fastened to the valve by the cover only. When covers are removed, electrical operation cannot be made. Racine Hydraulics & Machinery, Inc., Racine, Wis.

For more information—
Circle 77, inside back cover

Double Passage Rotating Joint

This joint can be used to handle either air or hydraulic pressures, where it is necessary to rotate two or more members inside each other. It is said to be so constructed that there cannot be any thread strains in the event there is run-out of any of the individual rotating members. These joints are manufactured with single, double or triple rotating passages. They are adaptable to bottle-filling machinery, packaging machinery and all types of machine tools where it is necessary to control air or hydraulic cylinders during rotating or oscillating movements.

These joints require no packing. This joint is capable of handling different medium through the different rotating passages at the same time. They are manufactured with connections $\frac{1}{4}$ in. and larger. Rotherm



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BUSHINGS

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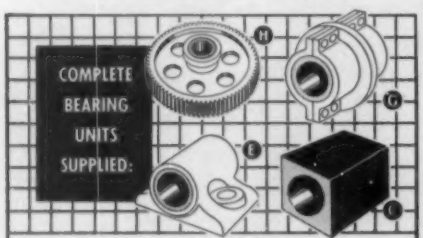
GRAPHALLOY is widely used for self-lubricating piston rings, seal rings, thrust and friction washers, pump vanes.



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GRAPHALLOY has high-performance electrical properties: low electrical noise, low and constant contact drop, high current density, minimum wear!

Brush Holders and Assemblies, Coin Silver Slip Rings and Assemblies available.

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Warner & Swasey engineering has long held the respect and admiration of machine tool users. This was forcibly demonstrated again when 88 shops ordered the new Warner & Swasey 2AC Automatic Chucking Machine before even the *first* one was ever built. Cutler-Hammer is proud to salute a company that can win and justify such confidence by performance. Nothing else can do it. We are also proud that Cutler-Hammer Motor Control plays a part in this performance. Hundreds of Warner & Swasey 2AC Automatics in use all over the country today commend the engineering judgment that equipped them with Cutler-Hammer Motor Control. CUTLER-HAMMER, Inc., 1332 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ont.

THE MARK

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MOTOR CONTROL
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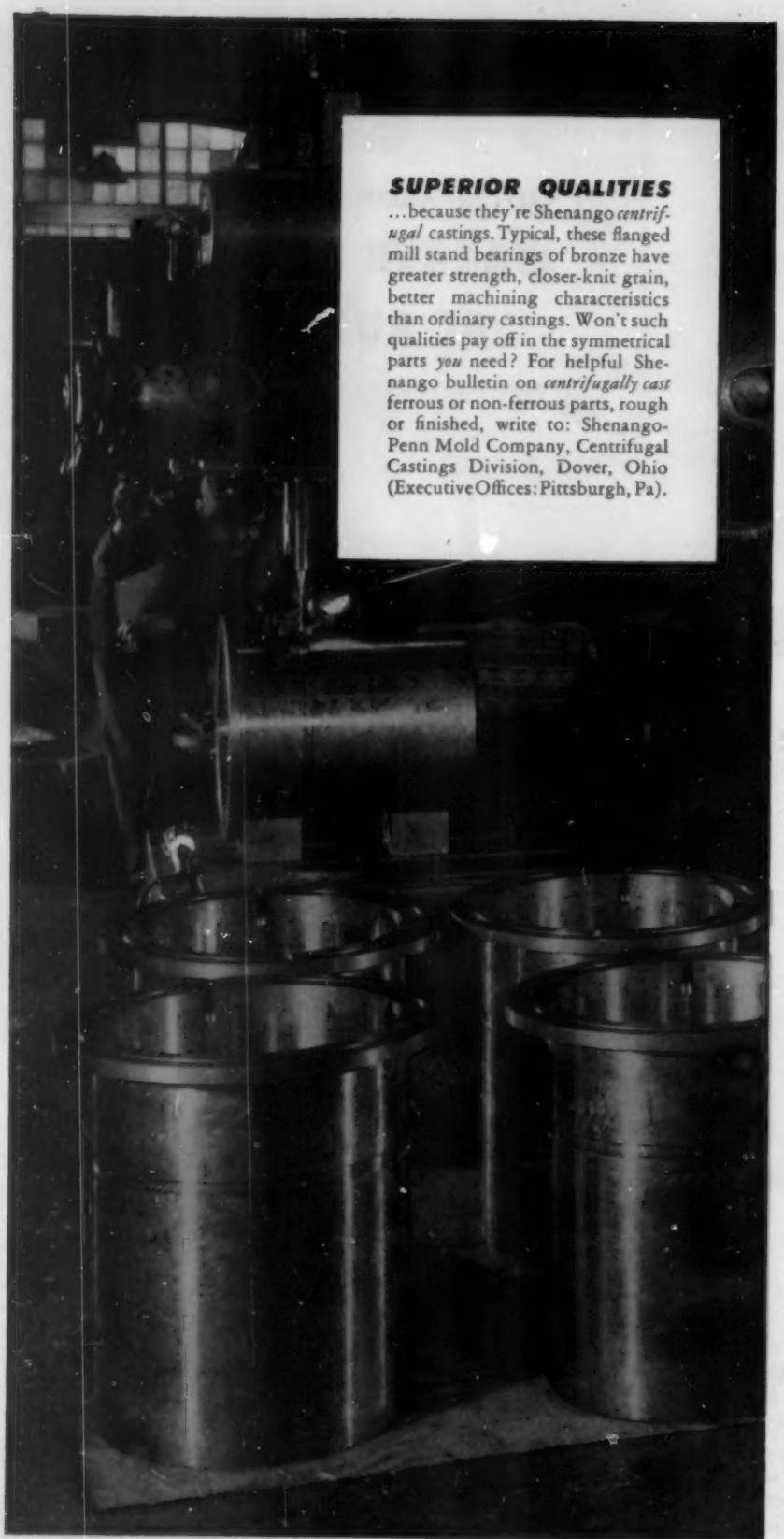
OF BETTER MACHINES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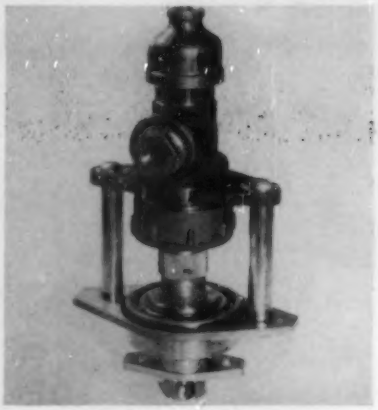

Engineering Company, Incorporated, 7280 West Devon Avenue, Chicago 31, Illinois.

For more information—
Circle 78, inside back cover

Three-Way Hand-or-Foot Operated Valve

With a built-in, full-flow capacity of 50 cfm at 50 psi, this valve was designed for air, oil, and water pressures of 0-200 psi and is recommended for small single-acting cylinders. It can be furnished either locking (two-positions standard) or non-locking. A spring return is also available, allowing both poppet elements to remain on seat. All non-locking models can be supplied with spring return for "on" or "off" positions.

Available in ¼-in. pipe size, the valve body is made of aluminum alloy 195 (heat treat T 62) and poppets are hard brass. Maximum operating temperature is 175 F. Airimatic Valve, Inc., 7317 Associate Ave., Cleveland 9, Ohio.

For more information—
Circle 79, inside back cover

Low Pressure, Direct Lift Solenoid Valve

Designed for low pressure application up to 7 psi, this valve is available in ⅜ and ½ in. pipe sizes. The unit has a forged brass body and was designed primarily as a gas pilot-control valve on power boilers. It is expected to prove applicable to low pressure air and gas control on gas-fired ovens and furnaces, automatic dispensing units, vacuum holding applications and similar units.

The valve can be used to control

For Instrumentation, Low Pressure Air Circuits, Laboratory Work, Coolant Lines and many other applications.

Fittings Need Only Be Finger Tightened . . . Tubing Bends by Hand

NOW... Make Tubing Installations at a *FRACTION* of Time and Cost the IMPERIAL *Poly-Flo* Way

Whatever Your Tubing Connection Problem... Depend on IMPERIAL

- HI-DUTY FITTINGS (Brass and Aluminum)
- FLEX FITTINGS (Brass)
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- 45° FLARE FITTINGS (Brass)
- ERMETO FITTINGS (Steel)
- INVERTED FLARE (Brass)
- COMPRESSION (Brass)
- POLY-FLO FITTINGS (for Plastic Tubing)

Ask for Bulletin No. 3025

IMPERIAL POLY-FLO TUBE FITTINGS, used with polyethylene tubing or other plastic tubing, *offer tremendous savings in time and labor* through ease of assembly and installation.

INSTALLATION IS AS EASY AS THIS! .... Simply cut tubing to desired length with knife or scissors. Bend tubing, which is very flexible, by hand to fit installation. Slip tubing and reversible sleeve over tube support. Nut need only be finger tightened. A wrench is never necessary.

IDEAL FOR MANY APPLICATIONS . . . instrumentation, coolant lines, chemical, food and beverage plant equipment, low pressure air circuits, are but a few. Tubing is very tough and impervious to most chemicals.

FITTINGS AND TUBING furnished in ¼", ⅜" and ½" O.D. sizes. Tubing supplied in 4 colors—color coding quickly identifies circuits. Recommended for working pressures to 125 psi.—¼" O.D.; 100 psi.—⅜" O.D. Temperatures from —90° F. to +175° F.

ACCESSORIES include tube racks for mounting of tubing; quick-disconnect and other shut-off valves; and convenient make-up kit of tubing and fittings.

THE IMPERIAL BRASS MFG. CO. 552 S. Racine Ave., Chicago 7, Ill.

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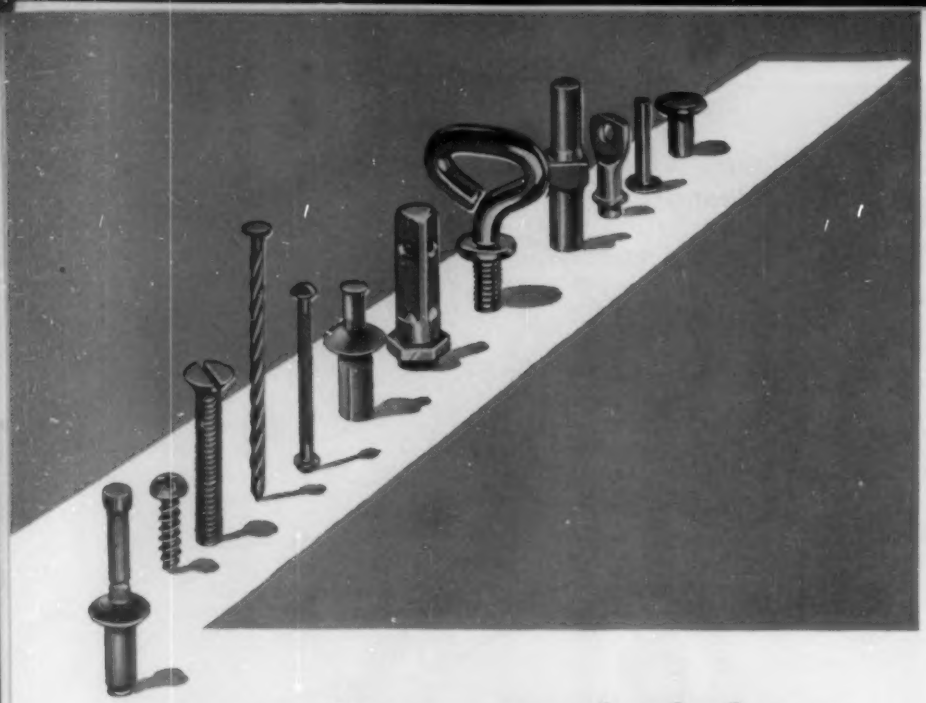
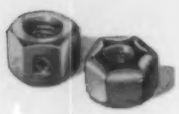
IMPERIAL

Industry's Most Complete Line of Tube Fittings and Tubing Tools





How to stay ahead of your competition with Townsend special fasteners and parts

In today's highly competitive markets many design engineers and production managers find they improve products, reduce material costs and assembly time with Townsend's method of cold-forming fasteners and small parts. It enables them to put greater value into their products and at the same time hold unit costs down.

The Townsend method often replaces costly, material-wasting methods with savings that range from $.70 to $80.00 per thousand. Annual savings are often substantial—$15,816 on an automobile door lock part—$12,000 on a washing machine fastener—$11,190 on two parts for home laundry equipment—$15,630 on two refrigerator fasteners—$5,130 on an electrical connection.

Townsend engineers specialize in the assembly and fastening of all types of materials for all industry. They draw upon more than 10,000 standard and special items developed in 138 years of cold-forming experience and rely upon Townsend's capacity to produce 60-million pieces daily to give you the best in fastening methods. To learn how to improve fastening efficiency, ask to have an engineer call.

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THE FASTENING AUTHORITY—Experience: *over 138 years*—**Capacity:** *sixty-million parts daily*—**Products:** *over ten-thousand types of solid rivets—cold-headed parts—Cherry Blind Rivets—Twinfast Screws—self-tapping screws—tubular rivets—locknuts—special nails—formed wire parts.*

Plants: *New Brighton, Pa.—Chicago, Ill.—Plymouth, Mich.—Santa Ana, Calif.*

In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

air, gas (manufactured and natural), propane, butane, water, gasoline, light fuel oil and other fluids to 180 F. Large-size ports ($\frac{3}{8}$ in. orifice) have been provided to assure greater flow at exceptionally low pressure drop. The normally closed valve requires 10 w to operate. When energized, the solenoid lifts the core and firmly attached disc directly off the seat. A closing spring returns the core and disc to a tightly-seated closed position when the solenoid is de-energized. Automatic Switch Co., Orange, N. J.

For more information—
Circle 80, inside back cover

Three and Four-Way Valves

Standard three-way models are available in sizes of $\frac{1}{4}$, $\frac{3}{8}$, and $\frac{1}{2}$ in., for manual or electrical control. Solenoid-controlled, pilot-operated models offer a choice of 115, 230, or 440-v operation. The same solenoid is used on all sizes.

Mechanically actuated models include hand lever, clevis, roller, foot pedal and treadle types. All actuators are readily interchangeable between valves of similar size. Valve bodies are of cast bronze. Bellows Co., Akron 9, Ohio.

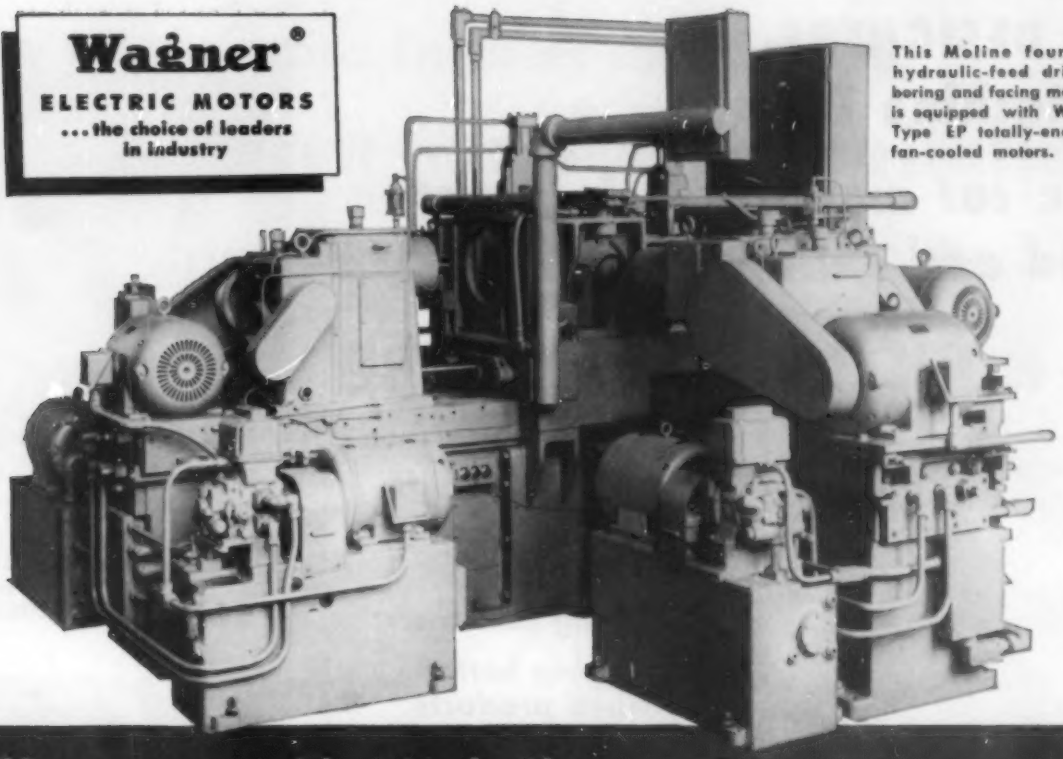
For more information—
Circle 81, inside back cover

Adjustable Flow Regulator

According to the model chosen, flow rates of this regulator vary from 0.5 to 12 gpm to 1.0 to 20 gpm. Body is aluminum and internal working parts are hardened and ground steel.

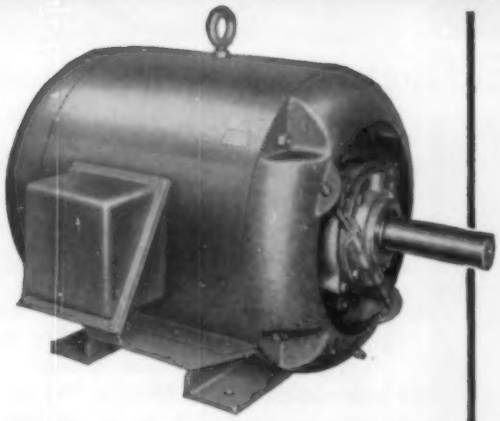
Flow is said to be controllable within 10 per cent of calibrated rate with differential pressures across the regu-

Wagner®
ELECTRIC MOTORS
...the choice of leaders in industry



This Moline four-way hydraulic-feed drilling, boring and facing machine is equipped with Wagner Type EP totally-enclosed fan-cooled motors.

Give your machine tools the *EXTRA ADVANTAGES* that Wagner Totally-Enclosed Motors provide



Wagner totally-enclosed fan-cooled motors are available in either steel or cast iron frame construction; in standard or explosion-proof types; single speed or multi-speed; single-phase, 2 phase or 3 phase; in ratings to 250 horsepower.

THEY ASSURE LESS DOWN TIME. Wagner totally-enclosed fan-cooled motors are *fully protected* against damage from steel filings, chips, dust, dirt, fumes and moisture. This built-in protection assures freedom from excessive down time caused by motor failure.

THEY REDUCE MAINTENANCE COSTS. Wagner totally-enclosed motors require no maintenance other than periodic lubrication. These motors are designed to run cooler and longer between maintenance periods, but when greasing is necessary, readily accessible lubrication openings permit addition of grease or a complete relubrication.

THEY ADD A PROVEN SELLING POINT. Wagner's reputation for building high quality motors of lasting dependability has made Wagner Motors the standard of many machine tool manufacturers. These manufacturers *know* that customer acceptance of the motor drive is an added selling point for their product.

Whatever your requirements may be, there is a Wagner Motor to fit every need. Bulletin MU-185 gives full information.

Your nearby Wagner engineer can help you select the *right* motors for your applications. Call the nearest of our 32 branch offices, or write us.

Wagner Electric Corporation EST. 1891

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6406 PLYMOUTH AVE., ST. LOUIS 14, MO., U.S.A.

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ELECTRIC MOTORS
TRANSFORMERS
INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

M55-8A

how DESIGNERS of Machine Tools

can *cut manufacturing costs* and *add selling features*

with NORGREN SPRAY-LUBE

SPRAY-LUBE is an improved system for applying cutting oil by means of compressed air. Spray is forcibly applied at the point of contact between the tool and work piece. The amount and quality of spray from each outlet is accurately controlled by simple adjustments.

ADVANTAGES OF SPRAY-LUBE. Better tool lubrication and rapid heat dissipation result in longer tool life and a better finished product. Tool maintenance and replacement costs are reduced.

Higher surface cutting speeds and increased depth of cut mean more machine output and lower unit costs. Working conditions are cleaner, safer, more efficient. Cutting oil consumption is greatly reduced.

Spray-Lube simplifies design work and reduces machine tool costs by eliminating the large coolant reservoirs, pumps and filters of recirculating systems.

For more facts about Spray-Lube results on specific applications, see cuts at right. Then write for Spray-Lube Brochure No. 491B or ask for a Spray-Lube demonstration in your plant.

TYPICAL EXAMPLES OF SPRAY-LUBE AT WORK

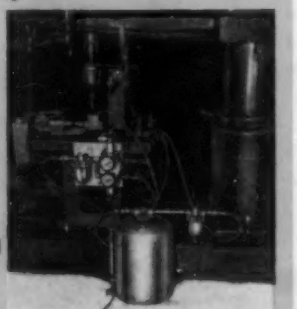
- *increasing tool life*
- *increasing machine output*
- *lowering unit costs*
- *producing better finished products*

for O. K. Rubber, Inc.

Doubled output on turret lathe; increased surface cutting speed from 45 to 75 fpm; eliminated welding of chips to tool and galling of work pieces.

for A-P Controls Corp.

Increased tap life, speeded up tapping operations; reduced maintenance costs; improved housekeeping.



for Standard Tool & Machine Co.

Increased machine output 35%; improved quality of work; eliminated hand lubrication.

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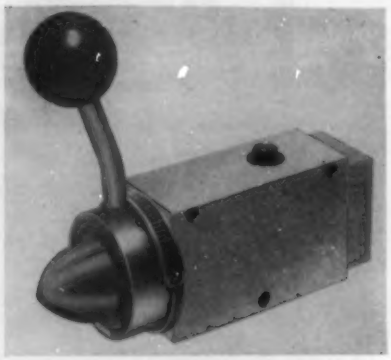
3428 So. Elati, Englewood, Colo.

Oil Fog Lubricators • Pressure Regulators • Air Filters Valves • Hose Assemblies



lator of 75 to 3000 psi. Weight is 4.5 lb and the unit is supplied ready for use with ½ in. pipe. Waterman Engineering Co., 725 Custer Ave., Evanston, Ill.

For more information— Circle 82, inside back cover

Timing Unit with Solenoid Valve

An electrical timer with solenoid valve, pushbutton station and signal light is available with various time ranges. After setting desired time once, cycles will repeat as initiated by the pushbutton. The pushbutton serves an additional function besides starting, in that it also can be used as an emergency stop, opening the circuit to the solenoid valve for as long as held, but not resetting the timer. Emmett Machine & Mfg., Inc., 445 E. Turkeyfoot Lake Road, Akron 19, Ohio.

For more information— Circle 83, inside back cover

Solenoid Pilot Valve

For automatic control of hydraulic circuits, this valve, of the sub-plate mounted type for panel mounting, is conservatively designed for full 3,000 psi.

Solenoids used operate on 3.6 amp

how a Lubrication Engineer converted to Norgren Micro-Fog Lubrication of bearings and gears on milling machine

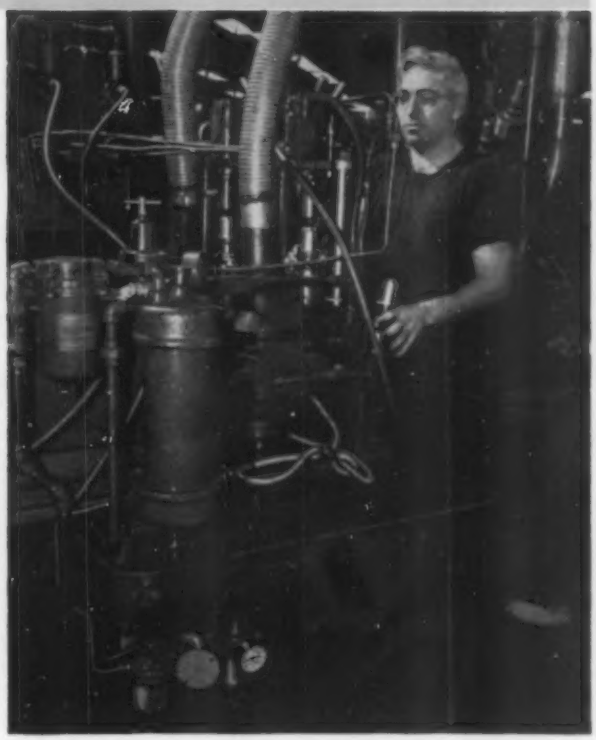
AND

- *eliminated serious heating problem*
- *improved milling accuracy*
- *reduced number of rejects*

A leading manufacturer of electrical automotive equipment uses machine illustrated for milling slots in cast iron distributor housings. When mill and power heads were packed with grease the machine ran so hot after an hour's operation that guide rods stretched, causing inaccuracies in location of milled slots.

A Norgren Lubro-Control Unit, Model 3765 FRV-2 was installed.

RESULT: Now, after 8 hours of continuous operation the machine operates at a temperature only slightly above ambient... milling accuracy has been greatly improved and the number of rejects substantially reduced.



Norgren integral Filter-Regulator unit (Model 5A2GG) filters grit, pipe scale and moisture from the compressed air, prevents contamination of oil supply and reduces main line pressure to proper working pressure; a Micro-Fog Lubricator (Model 30-41-2S) creates an air-borne oil fog, regulates rate of oil feed, and assures thorough, dependable lubrication of gearing and bearings in mill and power heads. A solenoid valve starts and stops the Micro-Fog lubrication system as the machine is turned on and off.

***DESIGNERS*... you can add important sales features to your machine tools with Norgren Micro-Fog lubrication... types and sizes of lubricators for small and large machines, with capacities up to 1000 bearing inches.**

FOR DETAILS ON ABOVE AND OTHER MACHINE TOOL APPLICATIONS AND TECHNICAL INFORMATION ON SYSTEM DESIGN, WRITE FOR NORGREN

BLUEPRINTS MF10 THROUGH MF18

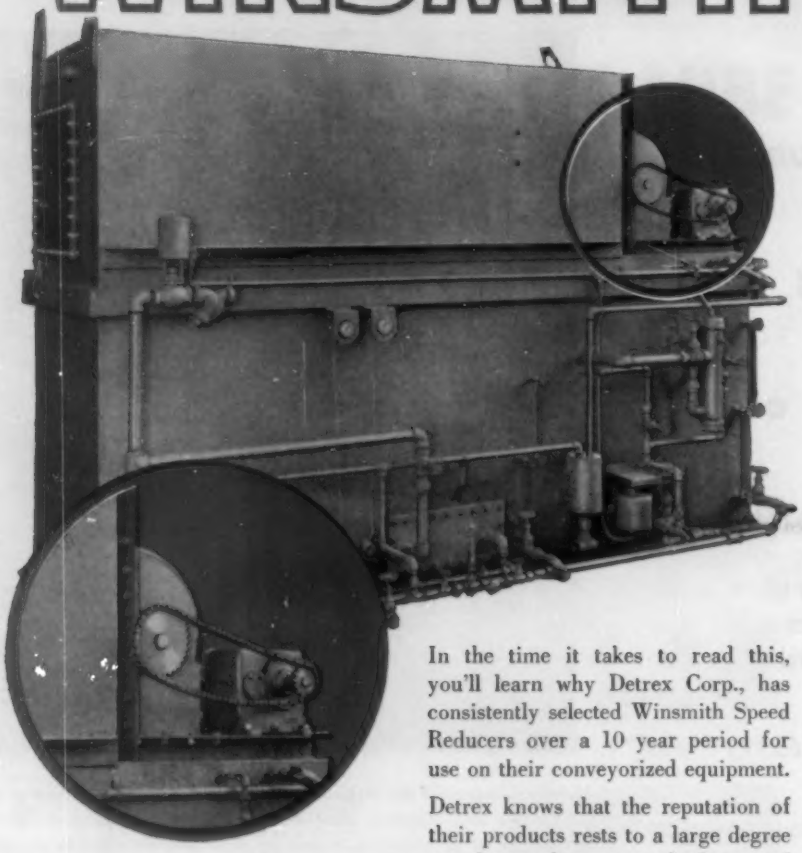
C. A. Norgren CO.
3428 So. Elati, Englewood, Colo.

Oil Fog Lubricators • Pressure Regulators
Air Filters • Valves • Hose Assemblies

In less than 5 minutes...

BENEFIT FROM DETREX'S 10 YEARS EXPERIENCE WITH

WINSMITH SPEED REDUCERS



Detrex selected a 4½ DB Winsmith Speed Reducer for use on their unique rotary basket gyro degreaser. Driven by a ¼ hp motor at 1750 rpm with a reduction ratio of 960 to 1, the Winsmith reducer provides a smooth, vibrationless operation that eliminates the possibility of damage to delicate machined parts.

In the time it takes to read this, you'll learn why Detrex Corp., has consistently selected Winsmith Speed Reducers over a 10 year period for use on their conveyorized equipment.

Detrex knows that the reputation of their products rests to a large degree on the performance of the speed reducer they select. *Dependability* is their prime specification . . . and, Detrex reports "Virtually no failures in 10 years" as the reason Winsmith Speed Reducers are continually used on equipment carrying the Detrex Name Plate!

Apply this 10 year record of dependability to your own speed reducer problems! In addition to ruggedness and reliability, you can count on Winsmith for the most complete line of speed reducers from a single source within the range of 1/100 to 85 hp. in ratios of 1.1:1 to 50,000:1. A Winsmith power transmission specialist is available to discuss your speed reducer applications. You'll find him listed in the classified section of your phone directory; or, write Winsmith, Inc. direct.

...a single source for the most complete line of speed reducers within the range of 1/100 h.p. to 85 h.p. in ratios of 1.1:1 to 50,000:1

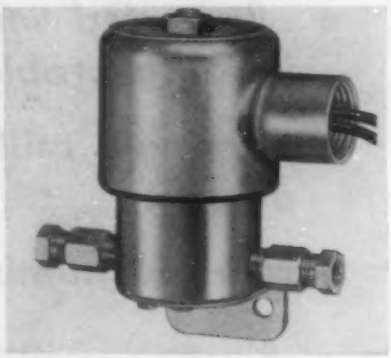
WINSMITH SPEED REDUCERS

WINSMITH, INC.
Springville, (Erie County) N.Y.

inrush and 0.45 amp holding at 115 v. Flow capacity is 3.6 amp at 15 ft per sec. Seven spool designs are available for any circuit control.

The valve is furnished in ¼ in. size with both double and single solenoids. Rivett Lathe & Grinder, Inc., Brighton 35, Boston, Mass.

For more information—
Circle 84, inside back cover

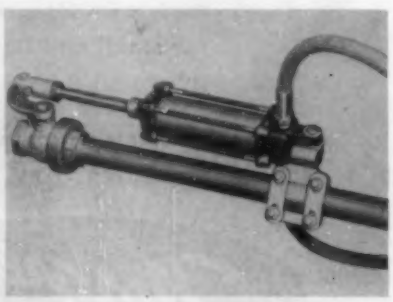


Noiseless Solenoid Valve

An electro-pneumatic switch has been developed whose spring, armature guide tolerances and material specifications are reported to be closely held to prevent a-c hum. When energized, the new valve passes full air at supply pressure up to 25 psi. When de-energized, the supply port is stopped and the return line pressure is wasted to atmosphere.

Port connections are ⅛ in. NPT and 60 cycle coils can be supplied for 115, 208, 230, or 440 v. The valve is UL-approved. Powers Regulator Co., Dept. PEN, Skokie, Ill.

For more information—
Circle 85, inside back cover



Air-Operated Ball Valve

This ball valve is for remote-control use. It can be installed in elevated or remote locations. Valves which are

'55 Forecast: MORE ALUMINUM PRODUCTS THAN EVER BEFORE

Reynolds ALUMINUM REPORTER

MODERN DESIGN HAS ALUMINUM IN MIND

★ ★ ★ Seventeenth in a Series to Industry on Aluminum Uses and Developments ★ ★ ★

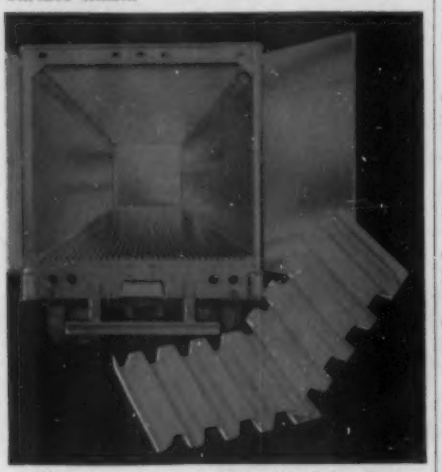
ROBERTSHAW-FULTON SWITCHES TO ALUMINUM

Extruded Trailer Flooring Pin-Points Advantages of Aluminum Extrusions

A good example of how design engineers can put aluminum extrusions to unique uses is found in one of Reynolds Metals Company's own recent developments—Extruded Trailer Flooring.

Chief feature of the new extruded flooring design is its interlocking joint. This watertight, self-fastening joint prevents water seepage, and eliminates the need for screw-holes through the top surface.

The interlocking joint is so designed that only the extrusion process could produce these flooring sections in one piece. This dramatizes the fact that extruding offers an infinite flexibility of design, free of the high cost of joining metal parts. Extrusion dies are also less expensive than rolls for structural shapes. And in this particular application, it is of special value that aluminum extrusions are straight, dimensionally accurate, and have better surface finish.



Aluminum extrusions are ideal for designs of this type because aluminum is rust-proof, strong, and so light it adds little to truck weight. On the job, these advantages translate into such features as lower maintenance, greater pay loads, less wear and tear, maximum strength, and easy cleaning.

Aluminum extrusions can save fabricating costs and increase efficiency. To help familiarize designers with the basic engineering principles that will enable them to use extruded aluminum shapes most effectively, Reynolds has prepared a 138-page handbook, "Designing With Aluminum Extrusions."

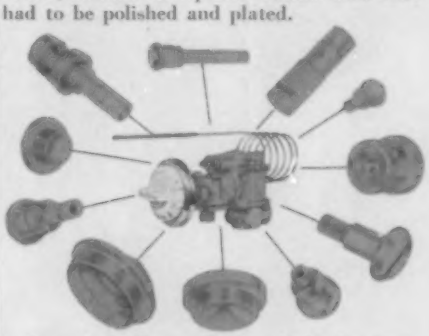
Single copies of this information-packed book are free when requested on your business letterhead to: Reynolds Metals Company, 2576 South Third Street, Louisville 1, Ky.

Reynolds Aluminum Standard Screw Machine Stock Offers New Advantages in Heat Control Manufacturing

The nation's leading manufacturer of appliance thermostats and heat controls, Robertshaw-Fulton Controls Company, is now using aluminum screw machine parts, replacing other metals. Improved quality, economy, efficiency and the superior machineability of free-cutting aluminum were the chief reasons company engineers gave for the switch to aluminum.

The use of aluminum in gas range oven thermostats has cut shipping weight approximately 1 lb. per item—and freight costs for materials are similarly reduced.

The fact that aluminum can be color anodized now permits Robertshaw-Fulton to color-code certain parts, eliminating an expensive number-stamping operation previously required. Color anodizing aluminum also cuts cost on exterior parts where appearance is a factor, because it replaces metals that once had to be polished and plated.



Several of the problems which aluminum solved for Robertshaw are unique to heat controls in contact with gases—but they dramatically illustrate the unexpected advantages of aluminum in manufacturing virtually any metal product.

The gas cock plug in oven range thermostats is exposed to high temperatures (250°—350°F) and other metals were not holding lubricating grease well at these temperatures. The grease, in this case, was necessary for adjustments—and aluminum solves this problem by holding grease properly even at oven heats.

In many areas, cooking and heating gases contain hydrogen sulphide. These "sour" gases have a corrosive effect on other metals. Aluminum, however, is not subject to corrosive attack by sour gases. And some gases, in contact with other metals, tend to break down and deposit carbon. This obstructs or ultimately shuts off the flow of gas, a highly undesirable effect which aluminum was found to eliminate.

Reynolds Aluminum can cut costs and increase product efficiency in your manufacturing operation, too. Let Reynolds engineers show you how.

To get their assistance, call your nearby Reynolds office listed under "Aluminum" in classified phone directories. Or write for more complete information and answers to your questions.

Aerol Engineers Choose Aluminum for High Quality Wheels and Casters

The aluminum caster shown below is one of a complete line of all-aluminum top-quality wheels and casters offered by the Aerol Co., Inc., Los Angeles. An Aerol engineer says, "The adaptability of aluminum to permanent mold casting provides the ultimate in modern materials handling media."

In order to produce superior wheels and casters, Aerol engineers and metallurgists selected Reynolds #356 aluminum ingot as the most suitable material, because of its high corrosion resistance, its high tensile strength, its minimum weight and its uniform sectional properties.

The high corrosion resistance of #356 aluminum alloy makes it ideal for casters which come in contact with moisture, detergents in normal solution, abrasives, brine, food products, or foreign matter.

To help you select the proper aluminum alloys for your particular products, regardless of your industry, Reynolds Metals Company has recently released a revised edition of the "Aluminum Data Book." Its 220 pages of detailed information on the properties and characteristics of aluminum is considered the most complete and up-to-date technical information on aluminum now available. Write for your free copy on your business letterhead. Address your request to Reynolds Metals Company, 2576 So. Third St., Louisville 1, Ky.

For the complete story on Machining with aluminum, send for a copy of "Machining Aluminum Alloys." Free when requested on business letterhead. Write Reynolds Metals Company, 2576 South Third Street, Louisville 1, Ky.

MORE INTERESTING NEWS ABOUT ALUMINUM ON NEXT PAGE

(Advertisement)

Printed in U.S.A.

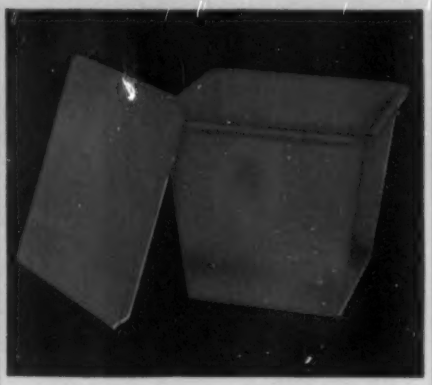
(Continued From Preceding Page)

Aluminum Revolutionizes the Bushel Basket

Among the wonderful business success stories of the past few years is that of Bucks County Enterprises, Inc., of Quakertown, Pa.—manufacturers of aluminum materials handling equipment. Starting as a two-man operation in 1947, Bucksco, as it is known, is selling its product from Maine to Florida.

Bucksco's success is a story of faith in aluminum. They have gone into one industry after another, found inefficient metal or wood equipment commonly used in those industries, then redesigned the equipment and fabricated it of aluminum. For example, 10 of the 11 major TV picture tube manufacturers now use Bucksco aluminum tube carriers. A simple Bucksco aluminum parts tray is credited by one manufacturer with saving 12 work operations and $20,000 annually. In the food and restaurant industry, Bucksco has designed numerous aluminum products now in wide use.

A recent example of Bucksco ingenuity with aluminum is the aluminum "bushel basket" shown here. Made of Alclad 2024-T3 aluminum, these Utili-Tainers are strong and light, and make full use of the space they occupy. They nest for easy storage. Strong lids make stacking precise and safe. Special multiple lids lock Utili-Tainers together for security in shipping, to prevent load shifting. And there is no danger of static electric sparks.



Bucksco revolutionized the bushel basket, by looking for new uses for aluminum. There is opportunity in almost every manufacturing business to follow Bucksco's lead.

What equipment in your firm's operation might be redesigned of aluminum, to save cost, time and labor?

Information is now available on how to design original structures with aluminum or convert present designs to aluminum, in the 130-page Reynolds Metals Company booklet, "Aluminum Structural Design." Write for your free copy, on your business letterhead, to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

Reynolds Metals Develops the World's Largest Aluminum Reduction Cell

The largest reduction cells ever operated in a commercial line producing aluminum is now being used in the two reduction plants recently built by Reynolds Metals Company. These two facilities, the San Patricio Plant, near Corpus Christi, Texas, and the Robert P. Patterson Plant at Arkadelphia, Arkansas, have a combined rated capacity of 270 *million* pounds of aluminum yearly.

The huge cell is from two to six times the size of other units now in use in this country. Each must be fed at a daily rate of 4000 pounds of alumina and approximately 1000 pounds of carbon anode materials. Each unit has a daily production capacity of approximately 2000 pounds of high grade aluminum.

Consumers are learning to look for this seal!

For details on how your company can qualify for the Seal, write Reynolds Metals Company, 2576 So. Third St., Louisville 1, Kentucky.

WHAT'S NEW

A Quick Look at New Reynolds Aluminum Products and Applications

Reynolds Aluminum Tread Plate

Reynolds now offers a standard aluminum tread plate with a raised diamond pattern on one side. The diamonds are set at right angles to each other on approximately one inch centers. The reverse side is flat.

¼ *Actual Size*

Reynolds Tread Plate is available in 6061 alloy and in thickness from .125″ to .500″, excluding the height of the raised diamonds.

Reynolds Aluminum Screen Wire

A .013″ diameter 5056-H392 Clad screen wire is now available from Reynolds. This product comes on either 5 lb. or 15 lb. capacity metal spools.

Quality of this new aluminum screen wire has been proved, both in tests conducted by Reynolds Metals Company and by screen cloth weavers.

Reynolds Aluminum Levelled Coil Stock

Here's a new Reynolds product that's ideal for electro-static precipitator plates, awning stock, building panels, store-front parts and any roll formed parts.

Levelled Coils will have less edge wave and buckle than commercial coiled sheet, making it especially suitable for applications where flatness is of prime importance.

Reynolds Levelled Coil Stock is available in 6 different combinations of alloys and tempers, in gauges from .020″ to .040″, widths from 6″ to 30″.

Reynolds Aluminum Plate Circles

Reynolds plate circles are now available in diameters from 7″ to 72″. This will be of special interest to agricultural chemical tank manufacturers (for making heads), as well as to manufacturers of heat exchangers (for tube sheets and baffle plates). Gauge range of the new plate circles is from ¼″ to 2″, in eleven alloys of "O" and "F" tempers.

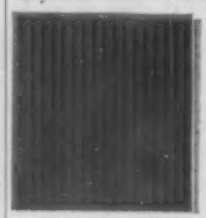
Reynolds Aluminum Shot and Notch Bar

Primary grade aluminum shot and notch bar of 99% plus purity is now available from Reynolds Metals Company. These products have several applications in the chemical industries, are used for high grade steel deoxidizing and for other alloying purposes.

The aluminum shot is solid, free from sharp points, and is a slightly flattened spheroid approximately 3/8″ in diameter, with a maximum size of ½″. The notch bars weigh about 3 pounds each.

Reynolds Fluted Sheet

A new fluted design has been added to Reynolds line of embossed aluminum sheet patterns.



½ *Actual Size*

Fluted sheet is of special interest to the architectural and building products industries, for such uses as spandrels, sun shades, kick plates and numerous other functional and decorative applications.

The pattern is on one side only, and it is available in thicknesses from .032″ to .125″, in 5 alloys and 2 brazing sheets, and 12″ to 60″ widths.

Reynolds Metals Issues New Book on "Aluminum Bridge Railings"

"Aluminum Bridge Railings", a new 52-page, 8½x11 manual containing 110 illustrations and 27 tables, is now available without charge.

This book includes a study of architectural considerations, complete design details, recommendations for joints, endings, and post settings, surface treatment, and installations.

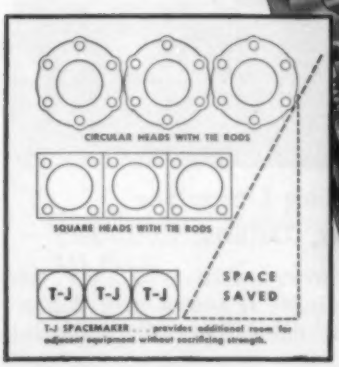
"Aluminum Bridge Railings" will be sent without charge upon request to *Desk PR, Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.*

First in performance for automatic muscle jobs like these...

T-J

Spacemaker
CYLINDERS

OFF SHELF DELIVERY


CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
T-J
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SPACE SAVED
T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

- OIL pressure to 750—AIR to 200 P.S.I.
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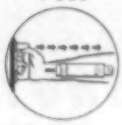
T-J Spacemaker Cylinders get first call for an ever-widening range of power movement jobs in industry today—because they're so advanced in design . . . so efficient and dependable in performance. Wide selection of styles and capacities. Check your needs now! Send for bulletin SM-454-2. The Tomkins-Johnson Co. Jackson, Mich.

PUSH

PULL



LIFT

Raise
Lock
Brake
Press
Spin
Turn
Grind
Weld
Lower
Squeeze
Bend
Coin
Saw
Tap
Index
Braze
Open
Time
Blank
Cut
Broach
Drill
Sequence
Close
Snub
Form
Pierce
Feed
Mill
Convey
etc.

T-J TOMKINS-JOHNSON
RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

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NEW BACK PRESSURE RELIEF VALVE...

SHUTS OFF TIGHT

WITH PRACTICALLY NO PRESSURE DROP BELOW RELIEF SETTING

EXTRA LARGE CAPACITY

For Pressures From 0 to 400 Pounds P.S.I.

Chatter Free • Low In Cost • Unusually Sensitive

- Available in iron, bronze, monel or stainless body. Size ½ to 2" inclusive, with bronze, monel or Neoprene diaphragm.
- Suitable for use on practically all fluids and gases. Especially suited for oils of all grades, including Bunker "C".
- For additional information on Type FR, and other new automatic valves in the Cash-Acme line, write our Engineering Department at the address below. To avoid delay, please include a brief outline of your pressure conditions and requirements.

Cash-Acme's Type FR back pressure relief valve automatically maintains correct pressure on the inlet side, by relieving into a lower pressure line. It is not affected by pressure variations on the discharge side. Provides protection against periodic high pressure conditions. Can be used with modification as a differential pressure regulator—holding a constant difference in pressures between valve inlet and valve outlet. Valve action is fully floating for smooth and even control. New patented "Floating ring" is unusually sensitive—gives exceptionally good closure. Large capacity in almost frictionless performance.

CASH ACME

A. W. CASH VALVE MANUFACTURING CORP.

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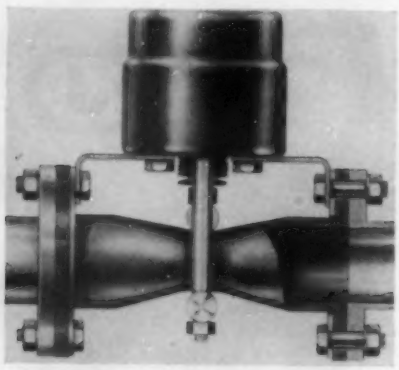
The Complete Cash-Acme Line Includes Pressure Reducing and Regulating Valves, Relief Valves, Back Pressure Valves, Vacuum Regulators and Vacuum Breakers, Differential Pressure Regulators, Strainers, Diaphragm Control Valves.

installed in danger areas can be safely operated from a distance. Control panels for the convenient operation of many scattered valves are also made practical. The new valves come in sizes from ⅜ to 2 in. Rockwood Sprinkler Co., 38 Harlow St., Worcester 5, Mass.

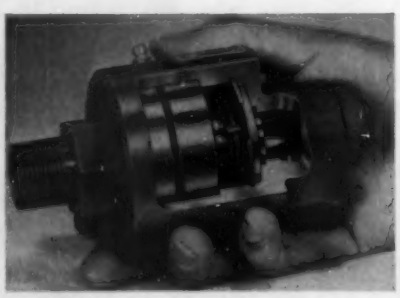
For more information—
Circle 86, inside back cover



Pinch-Type Valves

This straight-through, pinch-type valve consists of a flanged rubber body and self-supported, air-operated pinching mechanism. The Series Rx (high pressure) and Rz (low pressure) valves are said to give bubble-tight shut-off and may be had either with positioner for flow control, or without positioner for on-off service. The rolling diaphragm air motor is rated for 125 psi air operation. Valve sizes range from ¼ through 14 in., for 100 psi max line pressure and 180 F max operating temperature. R. K. L. Valve & Mfg. Co., Dept. 6, 1623 Elaine St., Phila. 19, Pa.

For more information—
Circle 87, inside back cover



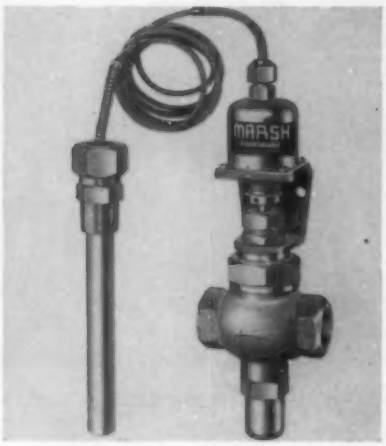
Rotating Union for Shafts, Drums, Cylinders

For water and steam to 300 F, this ¾ in. union is known as a double-purpose union, since all component

parts are alike for both ½ and ¾ in. service, with the exception of the rotors.

Changeover from through operation to entrance and return connection on the same side is possible. Alternate rotors for the Model 250 are available with the following thread specifications: ½ in. right hand or left hand pipe threads, ¾ in. right hand or left hand pipe threads, 1-in-14 right hand or left hand machine threads; also a 1-in-14 right hand pilot-type rotor for applications where close concentricity is required. Deublin Co., 1155 Waukegan Road, Glenview, Ill.

For more information—
Circle 88, inside back cover



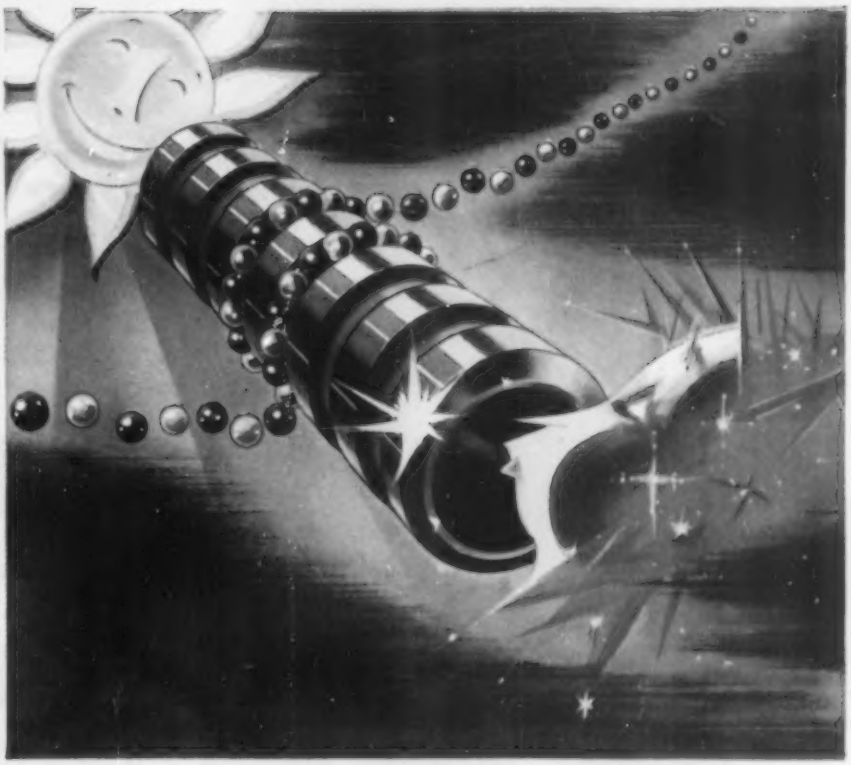
Temperature Actuated Valve

The Type WT is designed to control the flow of water, brine, oil, air, gas or other fluids used in cooling and other industrial processes. The valve opens with a rise in temperature and closes with a drop in temperature. Available in direct-operated sizes of ⅜, ½ and ¾ in. pipe size, and in pilot-operated sizes of 1, 1¼, 1½, 2, 2½, 3 and 4 in. Standard temperature ranges are 20 to 60 F, 60 to 100 F, 100 to 140 F, 140 to 180 F, 160 to 220 F. Liquid pressure range is to 150 lb; steam is limited to 15 lb. Standard capillary length is 5 ft. Electrimatic Co., Skokie, Ill.

For more information—
Circle 89, inside back cover

Diaphragm-Operated Air Ram

With a power factor of 15 times air line pressure, this ram has an extra



THIS SCREW ROLLING ON BALLS

operates in

high- and low-temperature areas

Over a wide temperature range, AEROL Ball-Screws which move entirely on steel balls eliminate the need for lubrication. They operate in high-temperature areas without danger of fire and thinned-out grease and in low-temperature areas without the problems of stiffened grease and sluggish operation. They also assure fast, precise, continuous positioning down to near-*zero* tolerance.

Replace the common high-sliding-friction screw with an AEROL Ball-Screw mechanism, and you can almost double drive efficiency, allowing you to save on motor size and weight, cost, space and electricity required.

These AEROL Ball-Screws are at work now on aircraft, on trucks and cars, on machine tools, on standard and special equipment of all kinds.

There may well be a money-saving opportunity to put them to work in your business. To get more information, write for our free booklet.

Cleveland Pneumatic
Tool Company CLEVELAND 5, OHIO

DEPARTMENT E-455

BALL-SCREW MECHANISMS • AIR-OIL IMPACT ABSORBERS

WORLD'S LARGEST MANUFACTURER OF AIRCRAFT LANDING GEARS

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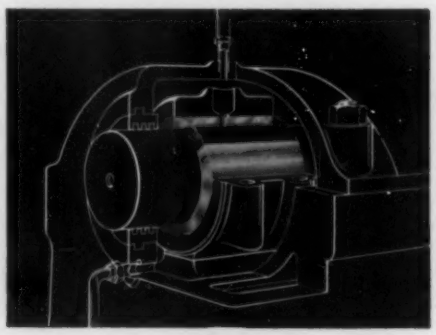
meets many needs

Cast Bronze Bunting Bearings can be supplied in many forms from the simplest to the most intricate. They offer many ways to cut the cost of both design and production without any sacrifice of performance or durability.

It may save you much expense and trouble to find out what Bunting Bronze Bearings can do for you. There is a Bunting engineer near you for consultation. Or write our Product Engineering Department at Toledo.

The Bunting Bearing offers ways to reduce the cost of a design and to employ designs that provide more economical production as well as lower initial cost.



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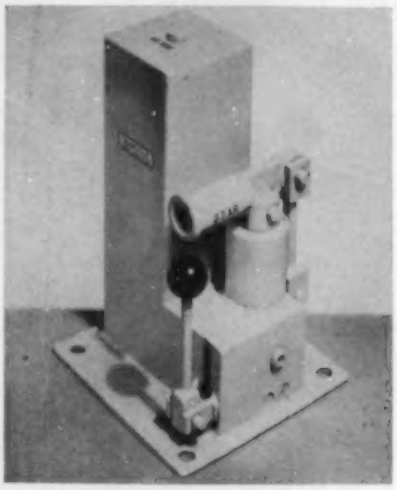
BRANCHES IN PRINCIPAL CITIES • DISTRIBUTORS EVERYWHERE

heavy duty diaphragm, rigidly gripped between two ground iron surfaces. No piston cups or packings are used. Lubrication is not required, the manufacturer states. The unit can be operated submerged in oils or solvents. The stroke is $\frac{5}{8}$ in. with spring return. Threaded ram screw has $2\frac{1}{2}$ in. adjustment. Any pressure up to 1 ton is obtainable when used with regulator. W. R. Brown Corp., 2701 N. Normandy Ave., Chicago, Ill.

For more information—
Circle 90, inside back cover



Hydraulic Two-Speed Concentric Pump

Automatic changeover from high speed, low pressure to low speed, high pressure in hydraulic pump operation is provided in a unit made entirely of steel. Available for hand and foot operation, the pump is activated by a single lever or pedal. Hydraulic rams are raised until a predetermined internal pressure is reached in the system. At this point, the job is taken over automatically by the specially designed high pressure concentric piston which generates as much as 10,000 psi. Star Jack Co., Inc., 420 Lexington Ave., New York 17, N. Y.

For more information—
Circle 91, inside back cover

Variable Cavity Pump

When the pressure in this pump reaches a predetermined point, a spring-loaded end plate moves outward, increasing the length of the pump cavity and enlarging the clear-

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File units for roll tracings are available. Individual trays protect each roll from dirt, tearing, and crushing.

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UnitSystem is a systematic plan for filing drawings and records according to use. You combine and arrange in an interlocking stack exactly the units you need to meet your individual requirements. You build higher stacks to save floor space. You add units as your requirements change.

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Drawings are easier to file and find, are better protected, because they are filed in units especially designed for them by size and use. The Shallow-Drawer Unit with special tracing lifters makes any active tracing easily accessible without damage to companion tracings. Vertical Filing Unit with index binders and compressors keeps active small sheets straight and upright without wrinkling or tearing. Five-Drawer Unit provides ideal storage for semi-active or inactive drawings and records by groups or projects.

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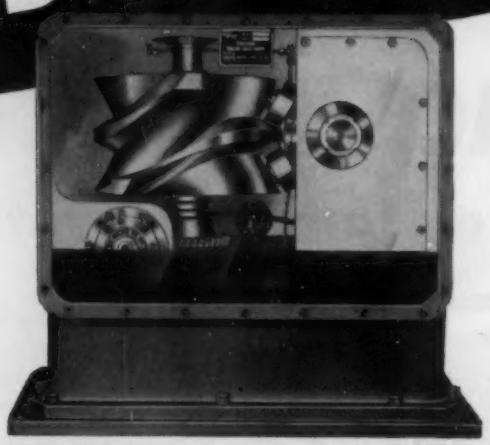

80% INCREASE IN PRODUCTION with the Ferguson ROLLER GEAR DRIVE

This housed Ferguson Drive with a plexiglass inspection plate was designed to replace a geneva drive on production machinery used by a west coast manufacturer requiring smooth, high speed PRECISION indexing. Read about the performance of this indexing mechanism . . .

". . . the operation to date has completely fulfilled our expectations. Even at top speed the machine is remarkably *free from vibration,* and indexing of the conveyor is *very smooth and accurate.* We have been able to handle one type of ware at *90 per minute with better results than at 50 per minute with the geneva drive.* It certainly looks as if the Roller Gear is the solution of our problem with the conveyor drive for this machine."

TREMENDOUS MARKETING ADVANTAGES

★ *Improve Product Quality!*
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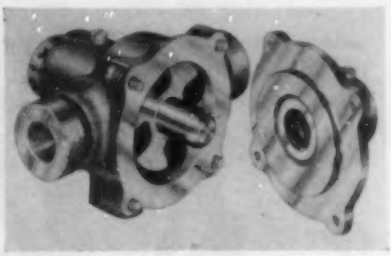
Manufacturers of the Ferguson Trans-o-Mator, Ferguson Roller Gear Drives, Dial Feed Index Tables, Roll Feeds for Presses, Special Cams, Special Purpose Machinery.

FERGUSON MACHINE & TOOL CO., INC.

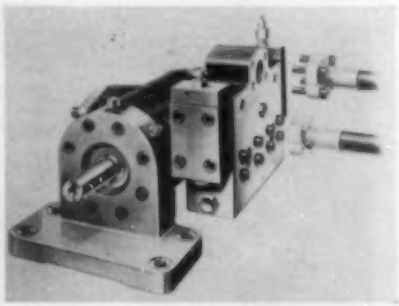
ROLLER GEAR DIVISION, DEPT. B-3 P. O. BOX 191, ST. LOUIS 21, MO.



ances between the ends of the rotor and the end plate. Increased clearances permit the liquid to recirculate, reducing the pump's maximum pressure. Pressures can be varied in this manner from 3 or 4 lb. up to 75 lb., the manufacturer states. When pressures drop, the end plate is automatically forced in by springs to reduce clearances.

Pump parts are available with either ⅜ in. internal pipe thread or external garden hose thread. The hollow shaft pump will slip directly onto a ½ in. motor shaft. Rollers are offered in nylon, stainless steel or rubber; pump case is bronze. Dep't KP, Hypro Engineering, Inc., 700 39 Ave., N.E., Minneapolis 21, Minn.

For more information— Circle 92, inside back cover



Hydraulic Pump Units With Integral Valve Panels

A series of 2,000 psi variable delivery hydraulic power units is now being offered as double pumps equipped with integral valve panels. Comprising two standard dual vane interchangeable pumping cartridges, with common drive shaft and common inlet but discharging through separate outlets, the new integral units may be used to supply power to two separate systems or to a single two-pressure circuit.

The pumping cartridges have capacities of 3, 5, 8 and 11 gpm, rated at 1,200 rpm. Total pump capacity ranges from 6 to 22 gpm, depending

ASCO

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When you discuss solenoid valve requirements with an ASCO Engineer, you are benefiting from the design and development experience of half a century. The ASCO specialist can recommend the *right* valve for your needs because that leadership has resulted in the more than 1300 types of solenoid valves now available:

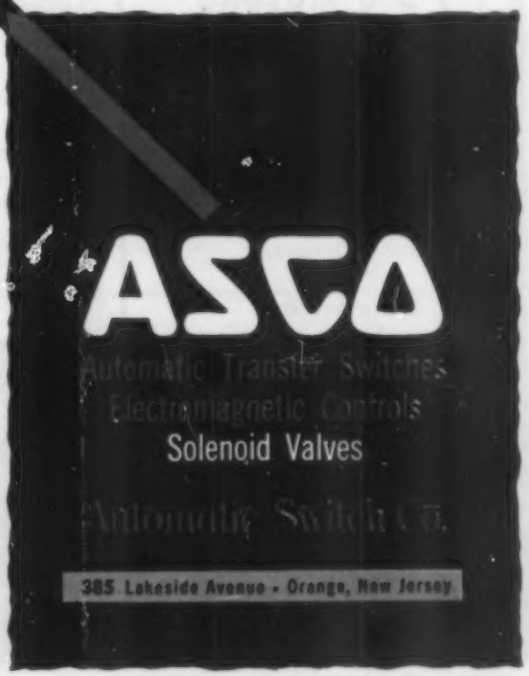
Two way valves in pipe sizes from ⅛" to 6" – for temperatures to 600° F. – for pressures to 1500 p.s.i.

Three way valves in pipe sizes from ⅛" to 6" – for temperatures to 450° F. – for pressures to 1000 p.s.i.

Four way valves in pipe sizes from ¼" to 1½" – for temperatures to 212° F. – for pressures to 500 p.s.i. – poppet or slide type.

And ASCO can supply you with standard, explosion-proof or water tight enclosures – Class A and Class H coils – a wide range of body materials including cast iron, brass, bronze and stainless steel.

There's *one* source that solves virtually any solenoid valve problem – ASCO. Why not have the ASCO Engineer call – or write for your copy of ASCO Solenoid Valve Catalog No. 24.



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Miehle Printing Press and Mfg. Co.
211 Bloomfield Ave., Bloomfield, N. J.

upon the combination of cartridges selected. The cartridges (or the cam rings only, if desired) are interchangeable to permit up to ten quick changes of capacity if the power requirements of the system change. New York Air Brake Co., 1700 E. Nine Mile Road, Hazel Park, Mich.

For more information—
Circle 93, inside back cover

Centrifugal Pump For High Heads

These 1½ hp pumps give heads to 150 ft at capacities to 53 gpm. Offered in cast iron, 316 stainless steel, Monel or Carpenter-20, these sealless centrifugals combine pump and motor in a single unit. Pumped fluid is allowed to circulate through the rotor chamber of the motor, isolated from the stator parts by a stainless steel liner. The standard model pump handles corrosive, evplosive and other fluids at temperatures to 450 F and pressures to 300 psi. Chempump Corp., Station D, 1300 E. Mermaid Lane, Philadelphia 18, Pa.

For more information—
Circle 94, inside back cover

Hydraulic Gear Pump Gives Up to 42 GPM

A gear-type oil hydraulic pump is recommended for continuous duty operation when pressures go as high as 2000 psi. Single pumps built in a range of size give a volume of discharge from 12 to 42 gpm at 1200 rpm. More than one pump can be built in tandem on one common shaft for direct connection to one power source, and yet each pump is independent of the others.

Volumetric efficiency is said to run higher than 90 percent. Commercial Shearing and Stamping Co., Youngstown 1, Ohio.

For more information—
Circle 95, inside back cover

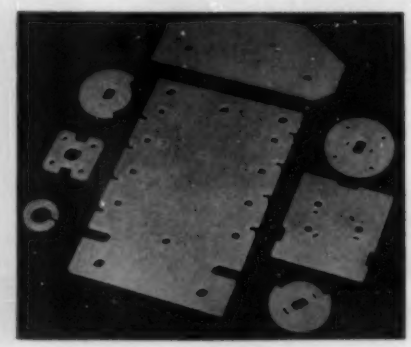
ENGINEERING EQUIPMENT

Punchable Electrical Insulation

This sheet is a cross-linked styrene resin, reinforced with glass fibers. Since the material has no cold flow, it is recommended for jack spacers, terminal boards, tight fitting contacts and similar applications where the part is under mechanical stress. It has been used for intricate-shaped punched parts where close tolerances, no surface crazing and a minimum of breakback are a necessity. Rexolite 2200 is readily postformed, with limited drawing, at temperatures of 150 to 170 C.

Sheets up to 36 x 36 in. are supplied in thicknesses from 0.032 to 0.250 in. inclusive. They are sanded to tolerance, which on 0.250 in. sheet is ±0.004 in.; on 0.078 in. and lower, tolerance is ±0.0025 in. Rex Corp., Hayward Road, W. Acton, Mass.

For more information—
Circle 96, inside back cover



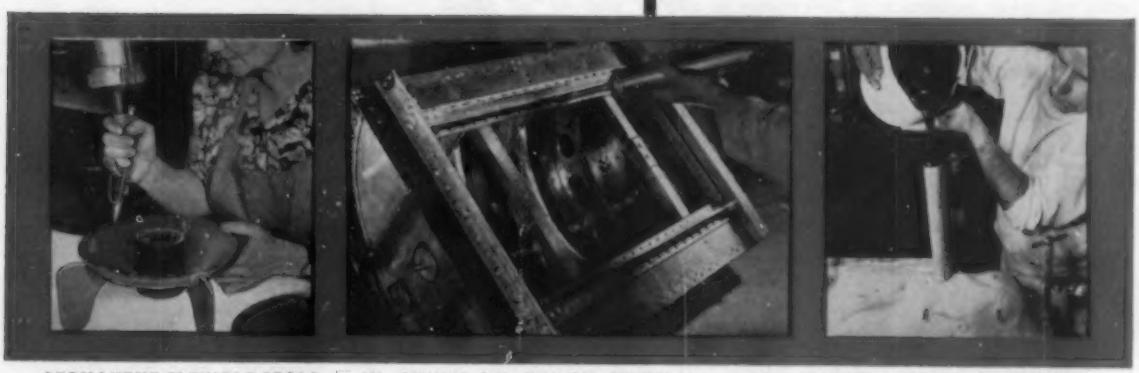
Precolored Aluminum

Coil and sheet aluminum, having an opaque finish said to resemble baked-on enamel or lacquer, is colored by an electro-chemical process of recent invention. In a test now being run, in which samples are being constantly exposed to cycles of 17 min of ultraviolet rays and 3 min of water spray, the colors have shown no apparent fading after 2647 hr of continuous exposure.

Identical colors are said to be produced in every cycle of manufacture, even if the cycles are separated by

Simplify your Production Methods with Thiokol® LIQUID POLYMER

A solventless liquid that converts to a rubber at room temperature without shrinkage.



PERMANENT FLEXIBLE SEALS for various equipment components such as washing machine agitators, explosion-proof motors, transformers, refrigerator glass.

Illustration courtesy of Minnesota Mining and Manufacturing Company, Detroit, Michigan.

OIL, SOLVENT AND CHEMICAL SEALERS for sealing aircraft wing tanks, equipment subjected to severe chemical exposure and various types of storage tanks.

COLD CASTING COMPOUNDS with a range of applications varying from patterns for aluminum investment casting to potting of electrical connectors.

Illustration courtesy of Perma-Flex® Mold Company, Columbus, Ohio.

"Thiokol" Liquid Polymer compounds can easily be flowed into place by pouring or by pressure-feed. They cure to elastomers with the following properties:

- Resilience and Toughness
- High Adhesive Strength
- Chemical, Oil and Solvent Resistance
- Good Electrical Properties
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The properties of "Thiokol" Liquid Polymer compounds simplify production methods and yield desirable product characteristics in the applications illustrated here.

"Thiokol" LP-2 may yield similar advantages in your product or process. Our technical staff will gladly discuss the suitability of "Thiokol" Liquid Polymer for any application you have in mind.

Thiokol Chemical Corporation supplies "Thiokol" Liquid Polymer only as a raw material. We will gladly indicate sources of suitable compounds to end-users.

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Shown Actual Size

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H®

'Diamond H' Relays

Continuing development of "Diamond H" miniature, hermetically sealed, aircraft type relays is constantly widening their performance range. Now, for example, in a 4 PDT relay: sensitivity to 85 mw with vibration resistance of 500 cycles at 10 "G" and 30 "G" shock resistance; vibration resistance of 55 to 2,000 cycles at 20 "G" with 50 "G" shock resistance and maximum sensitivity of 1½ watts.

Excellent contact reliability makes "Diamond H" relays preferred choice for critical jobs in vital applications ranging from guided missiles to high speed camera equipment.

TYPICAL PERFORMANCE CHARACTERISTICS

Vibration Resistance:	10-55 cycles at 1/16" double amplitude 55-500 cycles at 15 "G" 55-1,000 cycles at 15 "G" 55-2,000 cycles at 20 "G"
Temperature Range:	—55° to + 85°C. —65° to + 125°C. —65° to + 200°C.
Coils:	Resistances—1 ohm to 50,000 ohms Arrangements—single coil; two independent coils, either or both of which will operate unit
Insulation Resistance:	1,000 megohms at room temperature 100 megohms at 200°C.
Dielectric Strength:	450 to 1,250 V., RMS
Operating Time:	24 V. models 10 ms. or less; dropout less than 3ms.
Contacts:	30V., D.C.; 115V., A.C.; 2, 5, 7½ and 10A., resistive; 2 and 5A. inductive. Minimum 100,000 cycles life. Low interelectrode capacitance — less than 5 mmf. contacts to case; less than 2½ mmf. between contacts. Special Ratings: to 350 V., D.C., 400 MA., or other combinations including very low voltages and amperages or amperages to 20.
Operational Shock Resistance:	30, 40 and 50 "G" plus
Mechanical Shock Resistance:	up to 1,000 "G"
Mounting:	9 standard arrangements to meet all needs — plus ceramic plug-in socket.
Size:	1.6 cu. in.
Weight:	4 oz. or less

Call on "Diamond H" engineers to work with you in developing a variation to meet your specific requirements.

THE HART MANUFACTURING COMPANY
206 Bartholomew Avenue, Hartford, Connecticut

long periods of time. The new coating's flexibility, which permits it to be roll-formed or shallow drawn without marring its surface in the slightest degree. Aluma Kraft Mfg. Co., 1330 N. Rock Hill Road, St. Louis, Mo.

For more information—
Circle 97, inside back cover

Cellular Glass Insulation

Combining both insulation and ceramic finish, this material is said to provide an impact-resisting surface along with high insulating and moisture-proof qualities. Being made of pure glass, the material is resistant to nearly all chemicals. While the white ceramic surface needs no paint or other surface finish for durability and architectural appearance, various types of paint can be applied.

The standard size of the blocks produced is 18 x 12 in. The blocks are manufactured in two thicknesses, 3 and 4 in. Pittsburgh Corning Corp., Pittsburgh, Pa.

For more information—
Circle 98, inside back cover

Stainless Alloys Satisfy Various Specifications

These stainless steels are based upon new techniques of closer metallurgical control, so that one ananlysis now meets the specifications of the AISI, AMS, SAE, ACI and ASTM. Their use is expected to mean simplified stock and production records. Refined, pre-alloyed compositions are furnished in three convenient shapes, ready for casting; slugs, ingot and shot. WaiMet Engineering Co., 1999 Guoin St., Detroit 7, Mich.

For more information—
Circle 99, inside back cover

Color-Coded, Non-Rigid Tubing

Striped and solid colored non-rigid, thin-wall Teflon tubing can be wrapped around its own diameter without cracking. It has a high dielectric strength and can withstand temperature from —90 C to 26 C. Resistance of the tubing to acids and other corrosive materials is high. Teflon has zero water absorption and

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Merrill Aluminum Corporation

therefore the excellent insulation characteristics of the tubing are maintained even at 100 per cent humidity.

This tubing is available in diameters to accommodate wire sizes from No. 26 to No. 10. It comes in 10 ft lengths and can be easily cut with scissors for specific applications. It comes in 10 solid colors, and over 200 color combinations are available. Hitemp Wires, Inc., 26 Windsor Ave., Mineola, N. Y.

For more information—
Circle 100, inside back cover

Packing Made From Plastic Fiber

A Teflon yarn packing designed to function at higher peripheral speeds than braided or molded forms has been developed. The compound's antifrictional properties permit the packing to run substantially cooler. Available sizes are $\frac{1}{8}$ through $\frac{5}{8}$ in., $\frac{1}{16}$ in. graduations. Crane Packing Co., Dept. PEN 1800 Cuyler Ave., Chicago 13.

For more information—
Circle 101, inside back cover

ENGINEERING EQUIPMENT

Templates for Drawing Structural Cross-sections

Two templates for drawing strucings up to 24 x 36 in. onto a 12 x 18 in. scale of 1 in to 1 ft and the No. 28 in a scale of $\frac{3}{4}$ in. to 1 ft include I-beams from 18 to 3 in., broad-flanged I-beams 12 to 3 in., channels from 15 to 3 in., and angles from 8 to 2 in.

Templates can be used for smaller larger scales by using the respective smaller or larger cut-outs. Made of 0.030 in. matte finish plastic. All cut-outs are milled. Actual sizes are $8\frac{1}{4}$ x 5 in. (No. 27), 6 x $3\frac{3}{4}$ in. (No. 28). Rapidesign, Inc., Box 592, Glendale, Calif.

For more information—
Circle 102, inside back cover

Copies Engineering Drawings

Copying equipment which, it is asserted, will reduce engineering drawings up to 24 x 36 in. onto a 12 x 18 in. paper master and make possible 100 copies in about 5 min., has been announced. Medium-size drawings (12 x 18 in.) can be copied size-to-size, while several drawings at a time can be copied in the same size or enlarged individually to 12 x 18 in.

The equipment consists of a copying camera, charge unit, developing tray, cleaning tray, transfer unit and a fuser for making the image on the paper master permanent. The camera is equipped with a Goerz f/10 Artar process lens of $16\frac{1}{2}$ in. focal length, with a calibrated iris scale for maintaining constant exposure condtions with change in size of reproduction. Two 1000-w, 50-hr projection lamps are mounted on protruding arms of a glass-covered copying board, and the board itself, with $\frac{1}{4}$-in. registration marks along the center lines, tilts through a 90 deg arc from the horizontal to the vertical. Haloid Co., 555 Haloid St., Rochester 3, N. Y.

For more information—
Circle 103, inside back cover

High Voltage Dual Power Supply

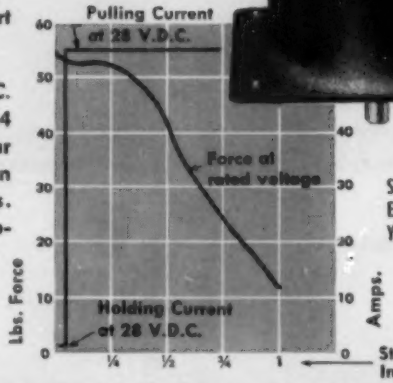
The Model D3-300D power supply provides two high-voltage output ranges, each independent of the other. It delivers 0-300 v, dc, at 300 ma max load, 0-300 v, dc, at 150 ma max load. D-c variable bias is 0-150 v at 5 ma max load, and 0-10 v, ac, unregulated, at 10 amp max load, which is variable with powerstat control. Regulation for line voltage of 115 v, ac, is

Decco DUAL WOUND D. C. SOLENOIDS

Compact Efficient Powerful

Because of its "Dual wound" construction the new Decco Series 29 D. C. Solenoid is able to deliver tremendous force in small space in continuous service. See Force Stroke Chart below.

This compact, new D.C. Solenoid is available in 24 to 250 Volt range, regular or waterproof construction —J.I.C. Specifications. Ideal for mobile equipment.



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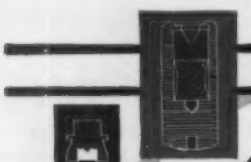

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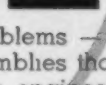
use *Bird* jewel assemblies

Why chance rejects and breakage that add to production costs when you can eliminate these time-wasting "headaches" with Bird complete jewel assemblies — ready to install in your equipment. Bird's many years of precision production mean jewel bearings of the highest quality These jewels are set according to your specifications by skilled craftsmen, in less time, for less money, and eliminate special set-ups in your plant.

Why not bring us your jewel problems — you specify — Bird will supply assemblies that fit your product and schedule. Our engineering staff is at your service for **all** your jewel bearing problems.



For information on jewel assemblies write for Bulletin 14.

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±10 per cent. The output voltage change is 0.15 per cent. For d-c regulated high voltage, the change from no-load to full load is less than 30mv. Ripple for both high voltage outputs is less than 500 microvolts rms. Dressen-Barnes Corp., 250 N. Vinedo Ave., Pasadena 8, Calif.

For more information— Circle 104, inside back cover

Direct-Coupled Amplifier

The Model D-1 amplifier can be used for many applications formerly requiring specialized instruments, according to its maker. Maximum useful overall gain is 80.000, while frequency response flat from zero to more than 100 kc is available at gain settings up to 10,000. A fully regulated power supply is in the instrument and the complete unit is designed for rack or bench mounting. Southwestern Industrial Electronics Co., 2831 Post Oak Road, Houston, Texas.

For more information— Circle 105, inside back cover

Air-Damped Accelerometer For Extreme Environmental Conditions

The 602A accelerometer features an air-damped spring-mass system which travels on precision bearings, eliminating side acceleration effects. Stable damping characteristics from −65 F to 200 F are maintained by the use of a damping orifice, according to the maker. Damping ratio can be adjusted to any value between 0.1 and 1.0 critical within a tolerance of ±0.05 critical. Operating mechanism is pressure sealed within an anodized aluminum case and meets government specifications covering protection against salt spray, humidity and fungus. Performance characteristics include resolution of 0.25 to

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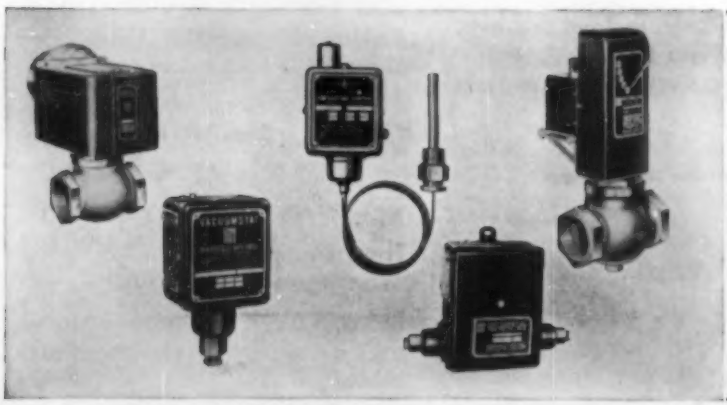

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New pump housing is more streamlined, more compact, better-looking! New G. E. Form "G" motor has pump rotor mounted on motor shaft, assuring smoothness and dependability. Light-weight sliding vanes provide positive, pulseless air delivery.

Resilient, rubber-cradled mounting dampens vibration and hush-quiets the entire unit. Pump delivers up to 1.3 c.f.m. running open at 1750 r.p.m., with 1/6 h.p. motor using only 3.8 amps.

Designed for original equipment applications, Model 0211 produces a maximum 25 p.s.i. or 27" vacuum — ideal for many automatic machines, industrial instruments and controls. Present O.E.M. uses include paper feeding in packaging, printing frames, liquid solvent agitators. Also used as a portable laboratory vacuum and pressure source.

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0.45 per cent or resistances of 5000 to 1000 ohm. Linearity is ±0.5 to ±1.0 per cent. Life expectancy is 1 million cycle. The unit is for use where total ranges are less than 20 G. Bourns Laboratories, 6135 Magnolia Ave., Riverside, Calif.

For more information— Circle 106, inside back cover

Variable Frequency Power Supply

The VFS-50 power supply is a semi-portable source of 45 to 2000 cycle a-c current, with available output up to 300 va. Vectron, Inc., 400-27 Main St., Waltham 54, Mass.

For more information— Circle 107, inside back cover

Power Supply Rated at 25 Kw

Rated at 230 v, dc, output when operated from a 230 v, three-phase 60-cycle a-c input. The unit has an inherent voltage regulation of 15 per cent and a maximum ripple of 5 per cent. Its overall dimension is 18 in. wide x 22 in. deep x 72 in. high. Perkins Engineering Corp., 345 Kansas St., El Segundo, Calif.

For more information— Circle 108, inside back cover

Meterless Comparison Instrument

This unit tests resistance or impedance, over the range of 100 ohm to 5 megohm, by comparing a component or circuit with a reference

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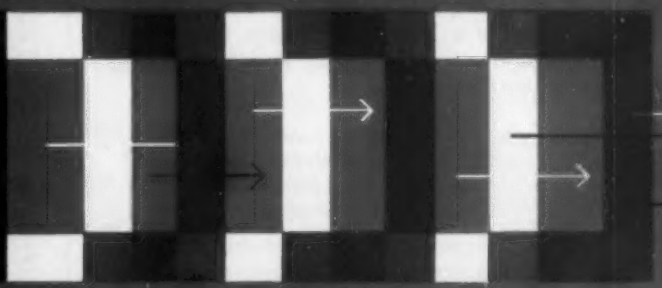

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For more information—
Circle 109, inside back cover

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For more information—
Circle 110, inside back cover

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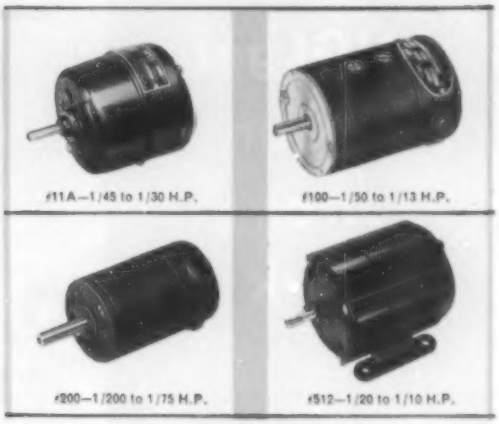

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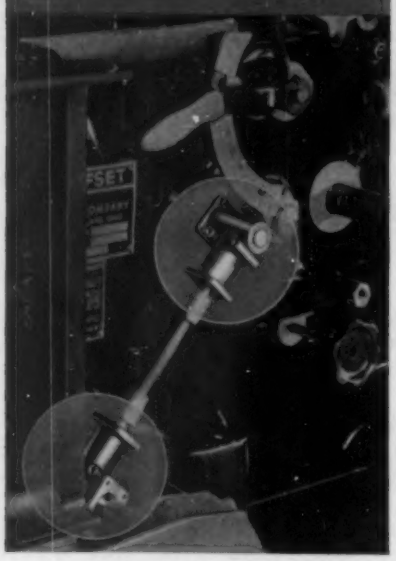

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

Wirebound Containers—Booklet, 15 pp, entitled, "What to Expect from Wirebounds," describes design, construction, materials. Wirebound Box Manufacturers Assn., 327 S. La Salle St., Chicago 4, Ill.

Circle 111, inside back cover

Automatic Ratio Relay – Bulletin 8410, 4 pp, describes automatic ratio relay which receives pneumatic input signals from two sources and transmits an output signal which is proportional to one of the inputs, with the degree of proportionality determined by the second input signal. Minneapolis-Honeywell Regulator Co., Wayne and Windrim Ave., Philadelphia 44, Pa.

Circle 112, inside back cover

Motorized Valve Assemblies—Bulletin 8506, 6 pp, gives information for selection of valve bodies, linkages and power units. Minneapolis-Honeywell Regulator Co., Wayne and Windrim Ave., Philadelphia 44, Pa.

Circle 113, inside back cover

Pneumatic Control and Transmission—Bulletin 1120, 44 pp, describes pneumatic controllers, their applications and how they work. Also describes pneumatic transmission systems and cascade, ratio and other interconnected control systems. Minneapolis-Honeywell Regulator Co., Wayne and Windrim Ave., Philadelphia 44, Pa.

Circle 114, inside back cover

Pneumatic and Hydraulic Components—Catalog, 120 pp, describes cylinders, valves and packaged fluid power devices and contains complete operating data, dimensions, optional mountings and other information. Modernair Corp., 400 Preda St., San Leandro, Calif.

Circle 115, inside back cover

Totally Enclosed Motors—Bulletin, 12 pp, contains cutaway, parts drawings, curve, data on induction-type electric motors of 1 to 30 hp. U. S. Electrical Motors, Inc., Box 2058, Los Angeles 54, Calif.

Circle 116, inside back cover

Phenolic Resins—Folder contains bulletins describing properties and characteristics. Marblette Corp., 37-21 30 St., Long Island City 1, N. Y.

Circle 117, inside back cover

Eddy-Current Brakes—Bulletin BR1, 11 pp. Standard units in both the air and liquid-cooled types are described. Construction details, capacities, characteristic curves, dimensions, and advantages are listed. Eaton Manufacturing Company, Dynamatic Div., Kenosha, Wisconsin.

Circle 118, inside back cover

Vertical, Solid Shaft Motors—Bulletin 1868, 8 pp, describes and illustrates electric motors in ratings from ¼ to 400 hp. Footless horizontal motors for direct connection are also included, in ratings from ¼ to 75 hp. U. S. Electrical Motors Inc., Box 2058, Los Angeles 54, Calif.

Circle 119, inside back cover

Automatic Control Components—Catalog 41, 36 pp, lists servo motors, motor tachometers, synchros, transformers. Servo-Tek Products Co., Inc., 1086 Goffle Road, Hawthorne, N. J.

Circle 120, inside back cover

Slotted Head, Self-Locking Bolts—Brochure, 4 pp, explains design and properties of bolts and provides a guide chart for use with average applications. Cleveland Cap Screw Company, 2917 East 79 Street, Cleveland 4, Ohio.

Circle 121, inside back cover

Parallel Shaft Gear Drives—Book 2619 32 pp, contains engineering data, including simplified horsepower tables, dimensions and overhung load capacities for selection from the standard line. Baseplates and built-in backstops are also covered. Link-Belt Co., Dept. PR, 307 N. Michigan Ave., Chicago 1, Ill.

Circle 122, inside back cover

Vibration Control—Bulletin 616, 12 pp, contains information on vibration,

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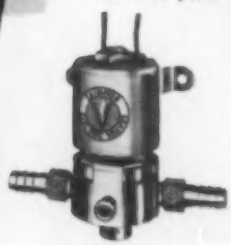

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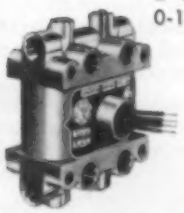

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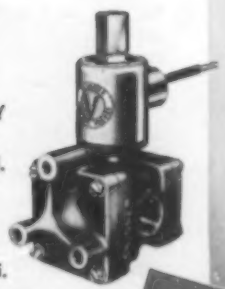

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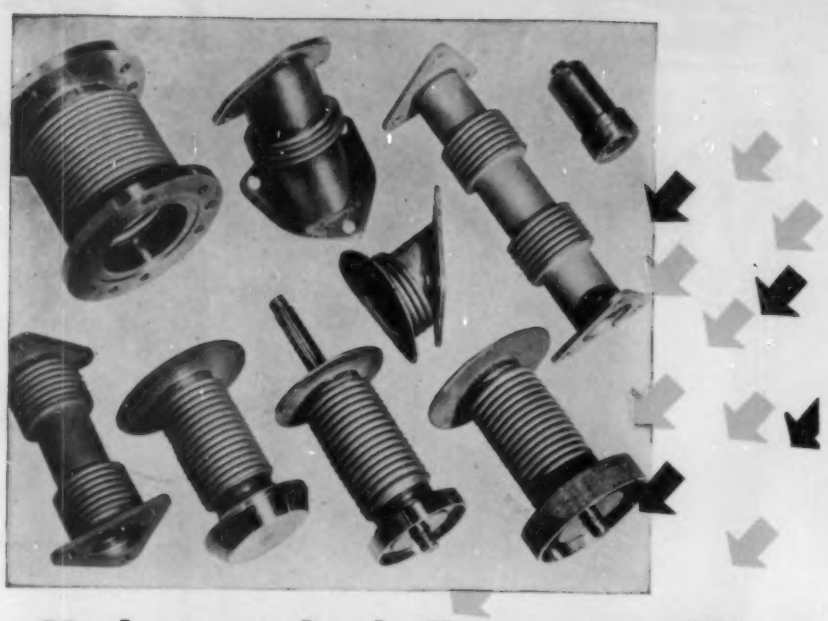

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useful charts and concise data on standard, special-performance isolators. MB Mfg. Co., Inc., 1060 State St., New Haven, Conn.

Circle 123, inside back cover

Copper-Base Castings–Booklet, 8 pp, provides composition and properties of high nickel content copper casting alloy. Waukesha Foundry Co., Waukesha, Wis.

Circle 124, inside back cover

Stainless Steel Castings–Booklet, 8 pp, contains descriptions, tabular data, recommended applications for various stainless casting alloys. Waukesha Foundry Co., Waukesha, Wis.

Circle 125, inside back cover

Temperature Controls–Catalog, 32 pp, contains descriptions, tabular data, mostats, relays, pressure and hydraulic-action controls. Included also are all controls for oil and gas-fired systems, solenoid gas valves and improved automatic pilots. White-Rodgers Electric Co., St. Louis 6, Mo.

Circle 126, inside back cover

Air-Hydraulic Pump–Folder, 4 pp, illustrates applications of a small volume, high pressure unit. Powermatic Sales Co., 258 Kenmore Blvd., Akron, Ohio.

Circle 127, inside back cover

Dual Element Pressure Transducer–Bulletin, 4 pp, describes unit that translates static and dynamic air pressures into equivalent voltages. Technology Instrument Corp., 531 Main St., Acton, Mass.

Circle 128, inside back cover

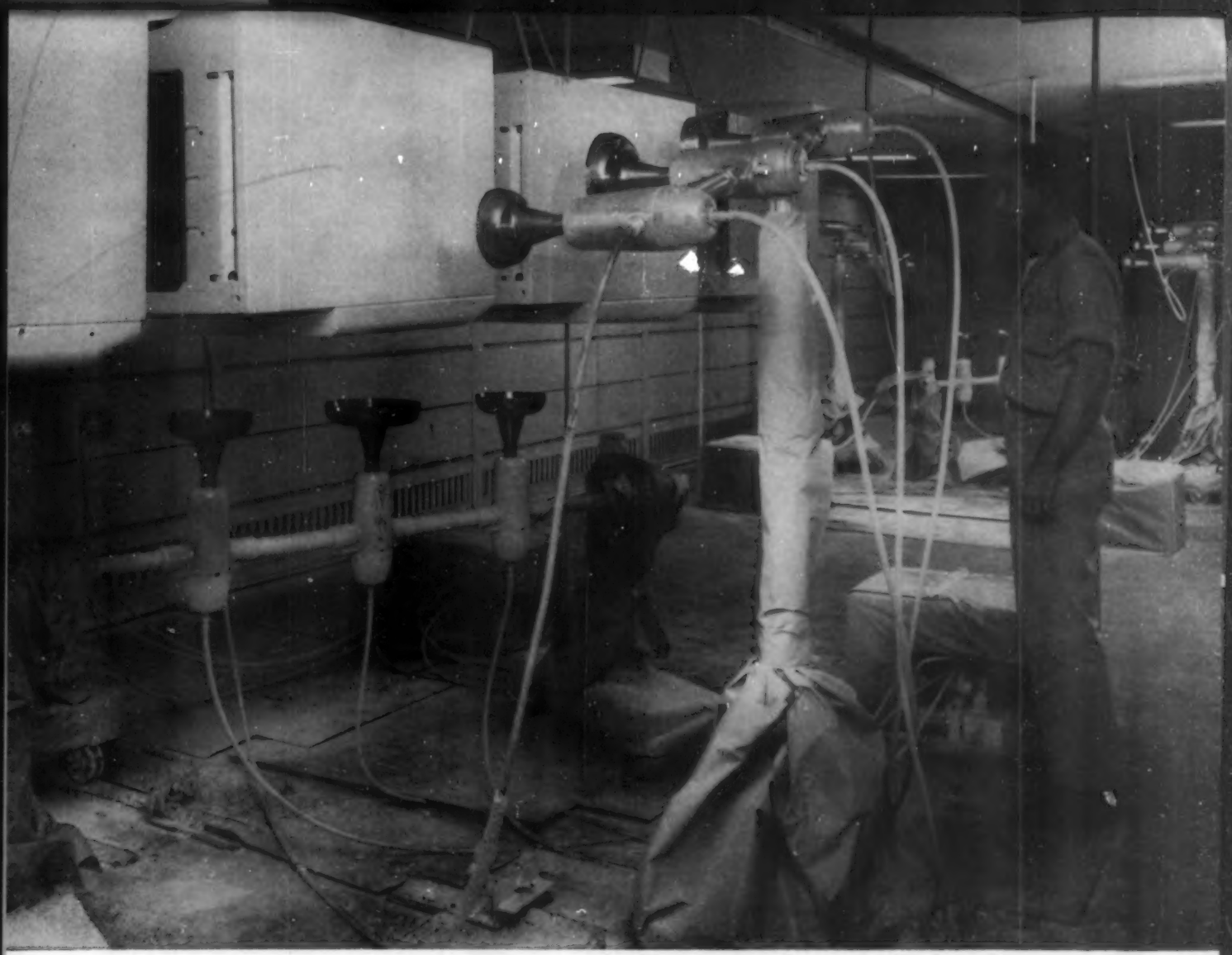
Mechanical Shaft Seals–Bulletin 10, 12 pp, discusses sealing applications involving pressures to 1000 psi, temperatures to 450 F, shaft speeds in excess of 3600 rpm and conditions involving corrosive fluids. Has diagrams of all standard and modified designs. Sealol Corp., 197 Post Road, Providence 5, R. I.

Circle 129, inside back cover

Flow Measurement and Control–Bulletin 115, 20 pp, gives information on rotameters. Brooks Rotameter Co., Lansdale, Pa.

Circle 130, inside back cover

Nylon Fastenings–Folder, 4 pp, contains information on properties and details of construction of all-nylon



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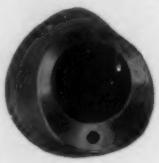

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Catalogs and Bulletins.....continued

fastenings. Anti-Corrosive Metal Products Co., Inc., Castleton-on-Hudson, N. Y.

Circle 131, inside back cover

V-Belt Drives—Catalog WBC-55-2, 74 pp, gives new horsepower ratings for V-belts and describes newly developed single "Q", "R" and "W" drives. American Pulley Co., 4200 Wissahickon Ave., Philadelphia 29, Pa.

Circle 132, inside back cover

Conveyor-Pulleys – Catalog CPC-55-2, 10 pp, has complete dimensional tables. New heavy duty pulley line is also explained. American Pulley Co., 4200 Wissahickon Ave., Philadelphia 29, Pa.

Circle 133, inside back cover

Speed-Reduction Drives – Catalog SRC-55-2, 16 pp, covers features and construction details and specifications. American Pulley Company, 4200 Wissahickon Avenue, Philadelphia 29, Pennsylvania.

Circle 134, inside back cover

Flat-Belt Drives—Catalog FBC-55-2, 12 pp. Included are specifications for steel split pulleys, motor pulleys, shaft collars, shaft hangers and bearings and motor bases. American Pulley Co., 4200 Wissahickon Ave., Philadelphia 29, Pa.

Circle 135, inside back cover

Magnetic Amplifiers—Booklet, 20 pp, explains basic theory underlying magnetic amplifier operation, gives information necessary for application and describes operating characteristics. Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

Circle 136, inside back cover

Rotary Limit Switch—Brochure, 4 pp, details applications and construction features. Gemco Electric Co., 25681 W. 8 Mile Road, Detroit 19, Mich.

Circle 137, inside back cover

Steel and Iron Casting—Folder, 8 pp, describes characteristics, list properties and carries engineering information on hardenability, section strength and comparative properties. American Brake Shoe Co., 230 Park Ave., New York 17, N. Y.

Circle 138, inside back cover

Safety Shut-Off Valves – Bulletin M-302, 4 pp, contains operating and construction details, cites application

examples, gives dimension tables. Eclipse Fuel Engineering Co., 1002 Buchanan St., Rockford, Ill.

Circle 139, inside back cover

Interference Filters–Catalog FSR, 22 pp, reviews line of rf interference suppression filters for use in screen rooms, induction heating equipment, diathermy and X-ray units or similar equipment which may produce radio interference. Filtron Co., Inc., Flushing, N. Y.

Circle 140, inside back cover

Slide Rules–Catalog 164A, 32 pp, describes metal slide rules from simple basic units through standard and special-purpose scale arrangements to the advanced dual-base log log vector hyperbolic with log log range 10^{-10} to 10^{10}. Pickett & Eckel, Inc., 1109 S. Fremont Ave., Alhambra, Calif.

Circle 141, inside back cover

Ceramic Parts and Assemblies–Bulletin 301, 4 pp, describes metallized and assembled types for electrical and electronic applications. Stupakoff Ceramic and Mfg. Co., Latrobe, Pa.

Circle 142, inside back cover

Centrifugal Pumps–Bulletin 1010, 16 pp, gives information on sizes, horsepowers, heads and capacities, dimensions, materials of construction, design data, construction features. Chempump Corp., Station E, 1300 E. Mermaid Lane, Philadelphia 18, Pa.

Circle 143, inside back cover

Air-Hydraulic Cylinders–Bulletin 55, 8 pp, has detailed drawings of various types of mounts. Complete dimensions for each mount 1½ to 8 in. bore are shown. An enlarged cut-a-way illustration shows detailed construction features. Accessory and engineering information also given. Hydro-Line Mfg. Co., 5742 Pike Road, Rockford, Ill.

Circle 144, inside back cover

Glass-Reinforced Plastic Parts–Bulletin GRP-1, 12 pp, describes high-pressure molding techniques and provides data on matched-die metal molding. American Hard Rubber Co., 93 Worth St., New York 13, N. Y.

Circle 145, inside back cover

Rotary Pumps–Catalog 955, 7 pp, describes adjustable relief valves as stand-

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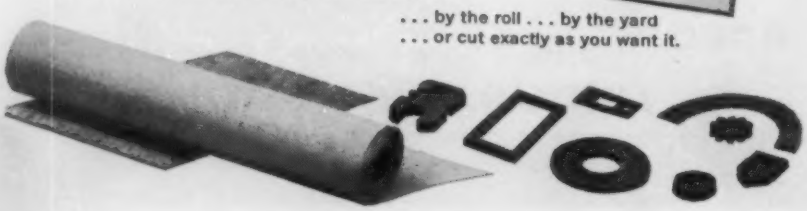

ard equipment on K Series pumps, internal construction of elevator pumps, low speed, high torque hydraulic pump-motors. George D. Roper Corp., Rockford, Ill.

Circle 146, inside back cover

Titanium Tubing and Pipe–Bulletin, 4 pp, describes two grades of titanium tubing and pipe. Physical properties of both grades are given together with data on corrosion resistance, machining characteristics, forming, welding, heat treating and cleaning. Carpenter Steel Co., Union, N. J.

Circle 147, inside back cover

Laminated Plastic–Booklet, 16 pp, provides data and figures on properties, characteristics of Formica die stock, engraving stock, molding compounds, copper-clad sheets. Formica Co., 4613 Spring Grove Ave., Cincinnati 32, Ohio.

Circle 148, inside back cover

Shaft Failures–Engineering Report 5, 2 pp. Basic fracture appearances of fatigue failures in shafts operating under various load conditions of reverse bending and rotation are shown in line drawings. Rodney Hunt Machine Co., Dept. IR, Orange, Mass.

Circle 149, inside back cover

Rack and Panel Connector–Bulletin DP9, 64 pp, contains descriptive index, detailed parts, exploded views, contact detail, data summaries, comparative shell sizes, mounting area information, wire and assembly data. Cannon Electric Co., 420 W. Ave. 33, Los Angeles 31, Calif.

Circle 150, inside back cover

Proportional Mixer–Bulletin, 4 pp, contains a selection chart, giving specifications and dimensions. Also included are capacity tables, listing gas capacity and blower pressure at 530, 2500 and 1000 Btu. Eclipse Fuel Engineering Co., Rockford, Ill.

Circle 151, inside back cover

Hydraulic Control Manifolds–Brochure, 4 pp, describes operation and application of hydraulic circuit control manifolds for hydraulically operated machines. Almo Tool Co., 11470 Kaltz, Centerline, Mich.

Circle 152, inside back cover

Welded Tubing–Handbook, 32 pp, covers range of sizes, gages and toler-

ances on square, round, rectangular steel tubing and special cold-formed shapes. It also provides physical properties, elements of sections and other data. Van Huffel Tube Corp., Warren, Ohio.

Circle 153, inside back cover

Power Supplies–Catalog, 8 pp. Sixty-four variations of single and dual supplies are described, including electrical, mechanical and construction specifications. New Jersey Electronics Corp., 345 Carnegie Ave., Kenilworth, N. J.

Circle 154, inside back cover

Industrial Hose – Catalogs describe welding, steam, air and petroleum hose, giving recommended uses, construction and specification as to size, weight and recommended working pressures. Boston Woven Hose & Rubber Co., P. O. Box 1071, Boston 3, Mass.

Circle 155, inside back cover

Silicone Grease–Brochure, 6 pp, describes silicone fluid-carbon black mixture designed for high-temperature, slow-speed bearings. Dow-Corning Corp., Midland, Mich.

Circle 156, inside back cover

Hydraulic Steering Systems–Bulletin M-5106, 4 pp. Circuit diagrams show four types of power steering systems based on components which can be assembled to fit a variety of installation and performance requirements. Vickers, Inc., 1400 Oakman Blvd., Detroit 32, Mich.

Circle 157, inside back cover

Heating Equipment–Folder GEA-6146, 4 pp, shows which type of heater to use for specific jobs, how to determine heater rating, how to calculate heat-up time, and how to select thermostats and controls. General Electric Co., Schenectady 5, N. Y.

Circle 158, inside back cover

Magnetic Disc Brakes–Bulletin BK 4002, 8 pp, describes brakes for motors of ⅛ through 50 hp. Contains drawings, tables, circuit diagrams. Dings Brakes, Inc., 4740 W. Electric Ave., Milwaukee, Wis.

Circle 159, inside back cover

Bronze and Iron Valves–Chart, 17 pp, lists figure numbers of valves of other manufacturers that are equiva-

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AISI 300 SERIES
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*MONEL
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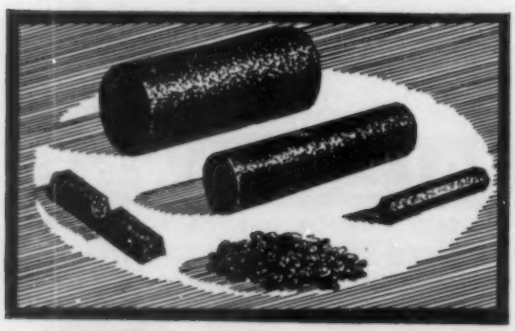

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lent in application. Fairbanks Co., 393 Lafayette St., New York 3, N. Y.
Circle 160, inside back cover

Hydraulic Pumps—Bulletin DP-350, 4 pp. Dimensioned drawings and specifications are included and construction features and performance characteristics are fully described. New York Air Brake Co., 1700 E. Nine Mile Road, Hazel Park, Mich.
Circle 161, inside back cover

Universal Joints—Catalog 2, 12 pp, covers applications, engineering data, models and sizes, proper joint selection. Gear Grinding Machine Co., 3901 Christopher, Detroit 11, Mich.
Circle 162, inside back cover

Magnetic Voltage Regulators—Brochure, 4 pp, describes regulator designed as equipment component. Circuit diagram, curves, table provided. Sorensen & Co., 375 Fairfield Ave., Stamford, Conn.
Circle 163, inside back cover

Motor Control—Booklet 5411, 46 pp, contains photographs, specifications and prices of magnetic starters and contactors, push buttons, combination starters, drum controllers, master, foot, limit and pressure switches. Furnas Electric Co, 1050 McKee St., Batavia, Ill.
Circle 164, inside back cover

Ten-Turn Potentiometer—Data sheet 54-06, 2 pp, lists specifications, construction, coil characteristics and available modifications. Helipot Corp., S. Pasadena, Calif.
Circle 165, inside back cover

Tube Fittings—Catalog 3500, 74 pp, describes lines of flare, compression, threaded fittings and various types of valves. Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago 7, Ill.
Circle 166, inside back cover

Standoff Terminals—Catalog sheets provide drawings, tables containing information on terminals for high frequency and miniaturized equipment. Garde Mfg Co., 588 Eddy St., Providence 3, R. I.
Circle 167, inside back cover

Heat-Resistant Glass—Bulletin B-91, 8 pp, describes composition, manufacture and application of 96 per cent silica glasses having high thermal

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See Miller Bulletins A-105K (Air) and H-104K (Hydraulic) for Complete Dimensions and Engineering Data on these "in-stock" sizes and other Custom Miller Cylinders in bores up to 20" and strokes up to 22 feet.

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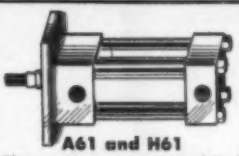
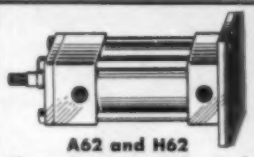
"A" Signifies Miller 200 psi Air Cylinders; "H", 2000 psi Hydraulic Cylinders. Interchangeable Mountings Are Shown In Red On Drawings.

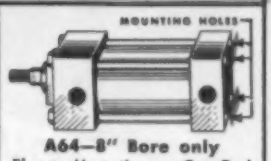


A61 and H61
Flange Mounting on Rod End

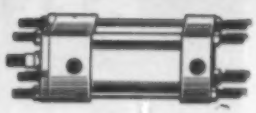


A62 and H62
Flange Mounting on Cap End

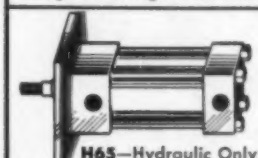
A63—8" Bore only
Flange Mounting on Rod End



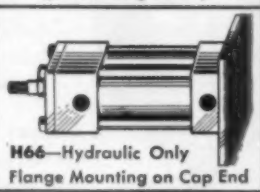
A64—8" Bore only
Flange Mounting on Cap End



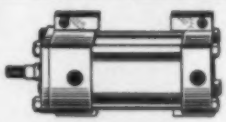
A50 & H50—Tie Rods not extended beyond nuts.
A51 & H51—Tie Rods extended both ends (shown).
A52 & H52—Tie Rods extended. Cap End only.
A53 & H53—Tie Rods Extended. Rod End only.
A54 & H54—Two Tie Rods extended at both ends.



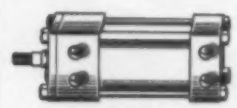
H65—Hydraulic Only
Flange Mounting on Rod End



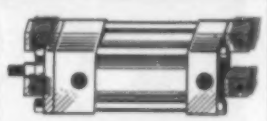
H66—Hydraulic Only
Flange Mounting on Cap End



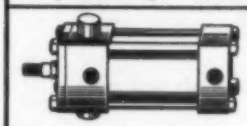
A72 and H72
Side Lug Mounting



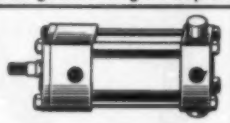
A74 and H74
Side Flush Mounting



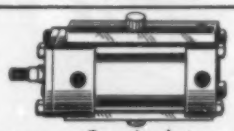
A77 and H77
Side or Foot Mounting



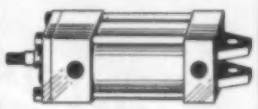
A81 and H81 Trunnion Mounting on Rod End



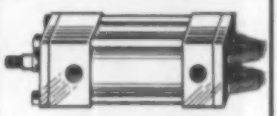
A82 and H82 Trunnion Mounting on Cap End



A83 and H83 Trunnion between Head and Cap (one week delivery)



A84 and H84
Pivot Mounting



A86 and H86
Pivot Mounting

IN STOCK BORES In Inches

AIR

BORES	ROD DIA.	ROD TURN DOWN & THREADS	"IN-STOCK" STROKES (in Inches)																						
1½	⅝"	7/16-20	Cushioned																						
			Non-Cush.	1	2	3	4	5	6																
2	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
			Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
2½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
			Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
3¼	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
			Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
4	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
			Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
5	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
			Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
6	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
			Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
8	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
			Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	

HYDRAULIC

BORES	ROD DIA.	ROD TURN DOWN & THREADS	"IN-STOCK" STROKES (in Inches)																						
1½	⅝"	7/16-20	Cushioned																						
			Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12										
2	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
			Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
2½	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
			Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
3¼	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
			Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
4	1¾"	1¼-12	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
			Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
5	2"	1½-12	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	
			Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36	

(4) (3) (2)

(1) "A" and "H" Models 82, 84 and 86 with strokes over 18" require stop tubes.

Column strength requires larger diameter piston rods for the following:

Air Cylinder Models A82, 84, and 86 with strokes inside area (1), when operated at 100 psi and over;

All hydraulic models with strokes inside area (2) and Models H82, 84, and 86 with strokes in area (4), when operated at 2000 psi and over;

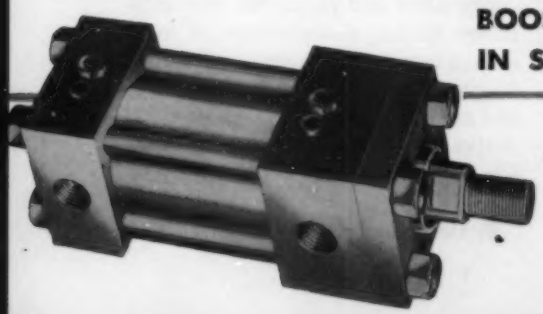
Models H82, 84 and 86 with strokes inside area (3), when operated at 1000 psi and over.

Depending upon Trunnion Pin location, "A" and "H" Models 83 with standard diameter piston rods can have longer strokes than Models 82, 84 and 86.

See Miller File #251 for oversize piston rod and stop tube requirements.

BOOSTERS IN STOCK

Immediate Delivery on the following Miller 25 to 1 Ratio Boosters (80 psi air input produces 2000 psi hydraulic oil output): Model B4, 5" bore, 1" dia. ram, 6" and 12" strokes; Reciprocating Booster Model DA77-RBA8, 5" bore, 1" dia. ram, 6" stroke. Also Booster Tanks, 5" dia., 6" and 10" heights.



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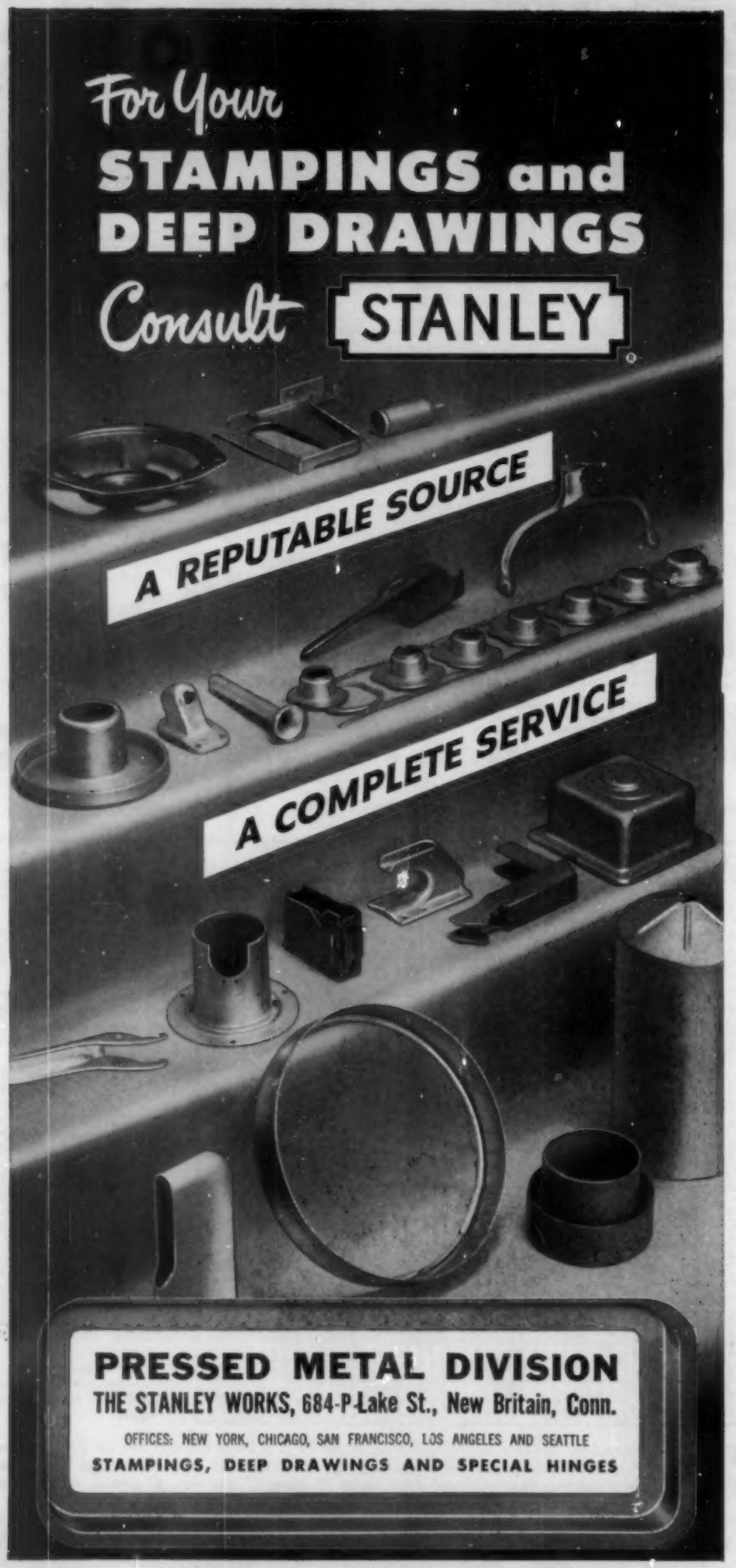
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shock resistance. Corning Glass Works, Corning, N. Y.
Circle 168, inside back cover

Spindle Shaft Couplings—Bulletin 58, 4 pp, contains information and illustrations. Ajax Flexible Coupling Co., Inc., Westfield, N. Y.
Circle 169, inside back cover

Plastic Pipe and Fittings—Catalog, 7 pp, describes properties, characteristics, available types and sizes of PVC pipe and fittings. Alpha Plastics, Inc., 14 Northfield Road, W. Orange, N. J.
Circle 170, inside back cover

Epoxy Resins—Folder contains bulletins describing properties and characteristics. Marblette Corp., 37-21 30 St., Long Island City 1, N. Y.
Circle 171, inside back cover

Beryllium Copper Springs—Catalog 9, 15 pp, contains technical and design data on compression, coil, flat, strip springs. Instrument Specialties, Inc., Little Falls, N. Y.
Circle 172, inside back cover

Non-Ferrous Forgings—Catalog, 8 pp, describes compositions, properties of copper, brass, bronze, aluminum forgings. Scovill Mfg. Co., Waterbury 20, Conn.
Circle 173, inside back cover

Letterhead Requests Only

Manufacturers who published following literature ask that requests for copies be made on company letterheads.

Speed Reducers—Catalog 55, 150 pp. Ratios and ratings for worm helical speed reducers are listed. Overhung load capacities are listed and explained. Tables showing detail dimensions of standard worms and gears are included. Horsburgh & Scott Co., 5114 Hamilton Ave., Cleveland 14, Ohio.

Magnesium—Handbook, 136 pp, for design engineers contains discussions, tables, curves, engineering drawings describing available alloys and their composition and properties; structural design factors; characteristics of magnesium castings, extrusions, mill forms, forgings; machining, forming, joining and assembly; finishing; available sizes, shapes and forms. Dow Chemical Co., Midland, Mich.

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Ad Libbing by the Editor

Henry L. Gantt was a great teacher as well as an outstanding creator. His heritage of unusual abilities was developed under the tutelage of the father of so-called "scientific management," Frederick Winslow Taylor.

He wrote a little pocked size book on the art of management. A tersely written book, it is easy and quick to read. In it one finds many gems of wisdom. Confuscius might have written them, so pointed are the statements. One is, "The authority to issue and order carries with it the responsibility of seeing to it that it is properly executed." Think that one over.

In spite of the fact that I had read and pondered over this statement for many hours, I still failed to remember it at a crucial time. It was at Harrisburg Steel. One of my men had failed to carry out an order that I had passed on to him from "up above." And what a mess resulted!

Boss Larkin had a way of putting things that made you feel foolish, kick yourself, and get furious with yourself. It was impossible to get "sore" at him for he always chided you with a chuckle and a wisp of a smile. You felt he was making fun of you and condoning you at the same time that he was scolding you.

In this particular instance I thought I had a good excuse. "I told that fellow *at least three times* that those gages were to be hardened on the night shift."

Larkin smiled, "You know, George, there was a fellow digging for gold. He dug and he dug. A number of times he thought of giving up, but each time started in again with renewed strength and determination. But finally he gave up.

"It was not long afterward that another prospector came along. The abandoned mine looked good to him, so he started in to dig. And the first shovelfull he turned up was pay dirt.

"You didn't hit pay dirt even the third time you told that fellow to have the night shift harden the gages. As a matter of fact, you didn't even know what you had hit because you didn't bother to analyze the effectiveness of the instructions you had given. In fact, you didn't give any instructions. You merely gave an order.

"Had you given instructions you would have told Bill what the situation was, why it was necessary to harden the gages that night and what would happen if the gages were not hardened. Then Bill would have had something to bite into and he would carry the picture in his mind until the job was done. But you just said 'Do it' or 'I want it done.' That might be all right for the army, but it is not the way to run a plant."

One seems to save a lot of time by merely blurting an order instead of giving instructions. But that is much like building a machine without prints. Sure you save a lot of design and print making time, but the final result is either a mess or costs many times more than it would have cost if the proper instructions or design had been given instead of merely an order to make the machine.—G. F. N.

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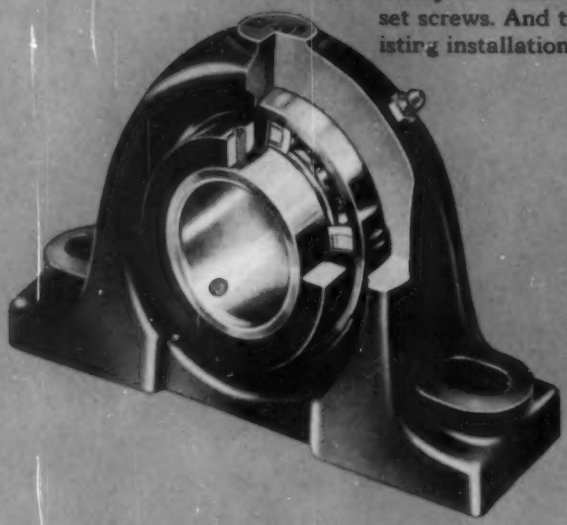

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See idea for design engineers on other side.

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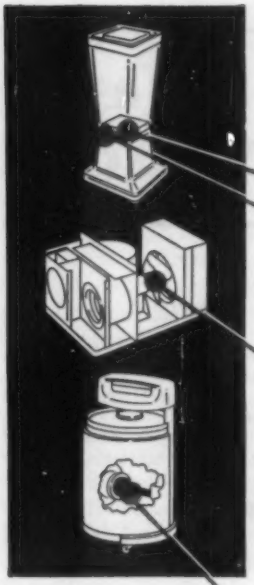

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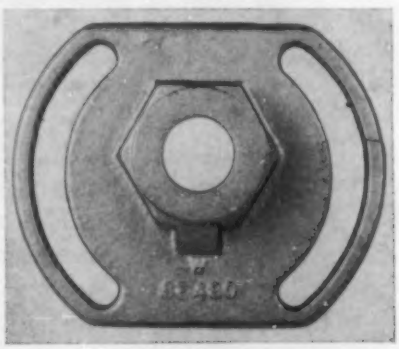
ENGINEERING ABSTRACTS

Malleable Gating

Abstracted from "Malleable Gating," by Lawrence Winings, Foundry Superintendent, Wagner Malleable Iron Co., Decatur, Ill., *American Foundryman*, January 1955. From a paper presented at the Metals Casting Conference, Purdue University.

Casting design is the most important factor in gating and feeding of malleable castings. There are three considerations in effective feeding of a casting: (1) design so that the heavy sections which feed liquid metal to lighter sections may also be fed liquid metal from some source. (2) Provide gate openings of sufficient size that the metal remains hot to feed liquid



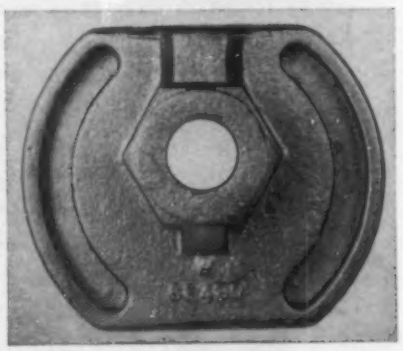


FIG. 1(A)—Part as originally designed. Because the center hub is so heavy compared to the surrounding flange, a bad shrink occurred around the hub. Also, cracks frequently resulted in the thin outside sections beyond the slots. (B) By adding a fillet from the edge of the casting into the hub, sufficient gate opening resulted to feed hot metal to the hub and prevent the shrink. Since 3/32 in. finish was originally specified for the opposite face, filling the slots to 1/16 in. added nothing to the machining cost but prevented the tendency toward rim cracks.

metal to the heavy sections. (3) Have feeders of sufficient size to supply liquid metal and to keep such metal in the gate opening during solidification of the casting.

Casting design is important because it is often impossible to properly feed an improperly designed casting regardless of the number and size of gates and feeders.

Illustrations shown point out changes in design of some specific parts which resulted in improved castings or simplified casting practice.

In addition to making the difference between sound or unsound castings, proper design can make possible savings in all the factors affected by gating. A change in design which makes it possible to feed a casting with one gate instead of two or three gives a better yield and brings about a cost saving in gate removal. Also it can mean a higher production rate because of more pieces in a mold, or a smaller flask size when less of the plate area is taken up by feeders and runner bars.

Many times a slight change in design will make possible a job without feeder cores, top feeders, or chills otherwise required. The result is a higher production rate at less cost.

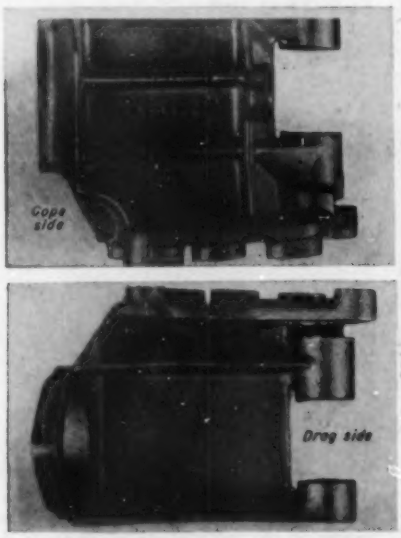


FIG. 2—By adding large fillets in the cope side of this automotive bracket, one directly in front of the gate that joins one of the end fillets to the overlapping drag fillet, and one along each end rib, shrinkage cracks were prevented that formerly occurred along the entire rib section directly behind the bosses and along both end ribs. Shrinkage was prevented by using a single gate, while formerly sound castings could not be produced even with four gates.

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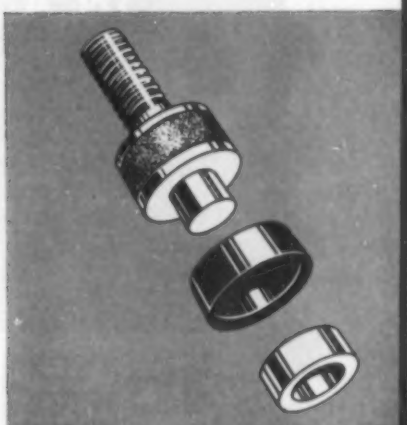

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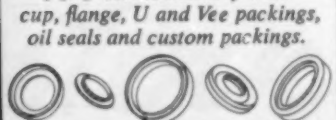

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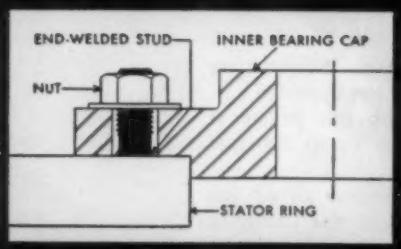

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Past experience indicates that the most common alteration required in a design is for addition of metal at the right place to facilitate feeding. This may be in the form of a lug or a fillet.

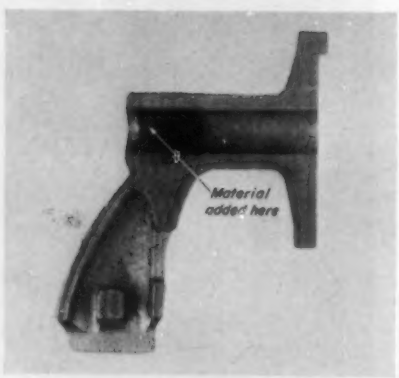

FIG. 3—Ordnance specifications required gating on the front of the plate or on the barrel of the gun only. With the original design (B), excessive shrinkage resulted at the point shown. The design prevented enlarging the core into the handle, so the section at the rear end of the barrel was made solid, as shown (C), to provide a source of liquid metal for the area where excess shrinkage occured. This extra metal was subsequently removed at time of machining.

(Continued on Page 294)

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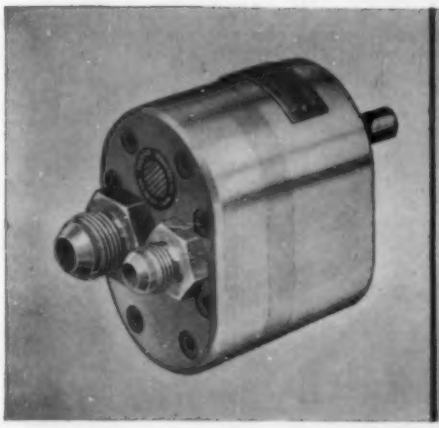

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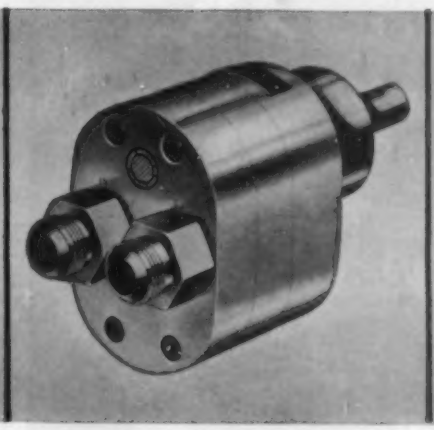

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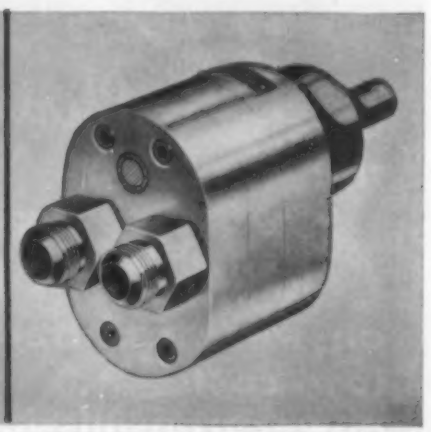

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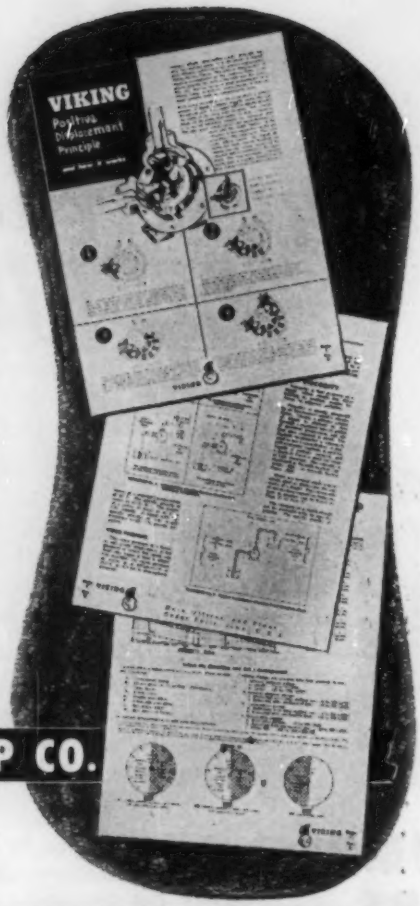

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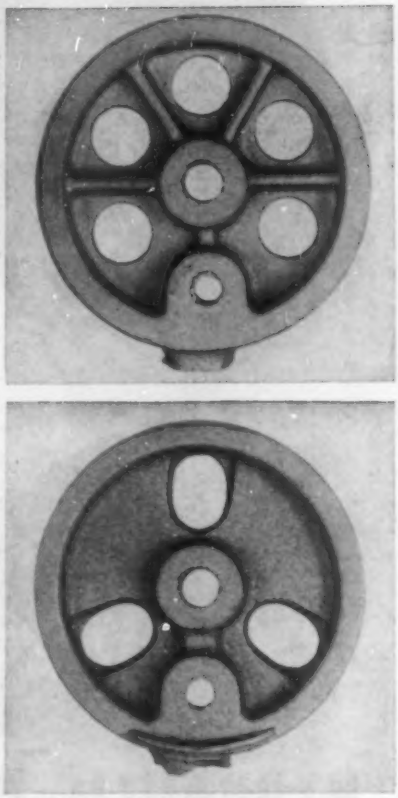


FIG. 4—A shrink occurred all around the center boss (A). As redesigned (B), the rib between the two bosses was enlarged to aid in feeding from the gate to the center boss. Elimination of two holes and the ribs, plus thickening of the web, essentially eliminated rejects.

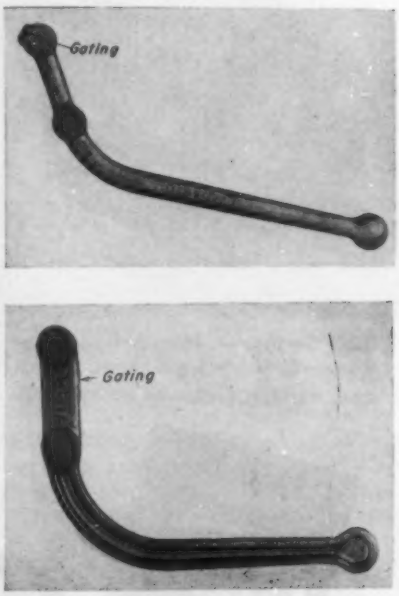
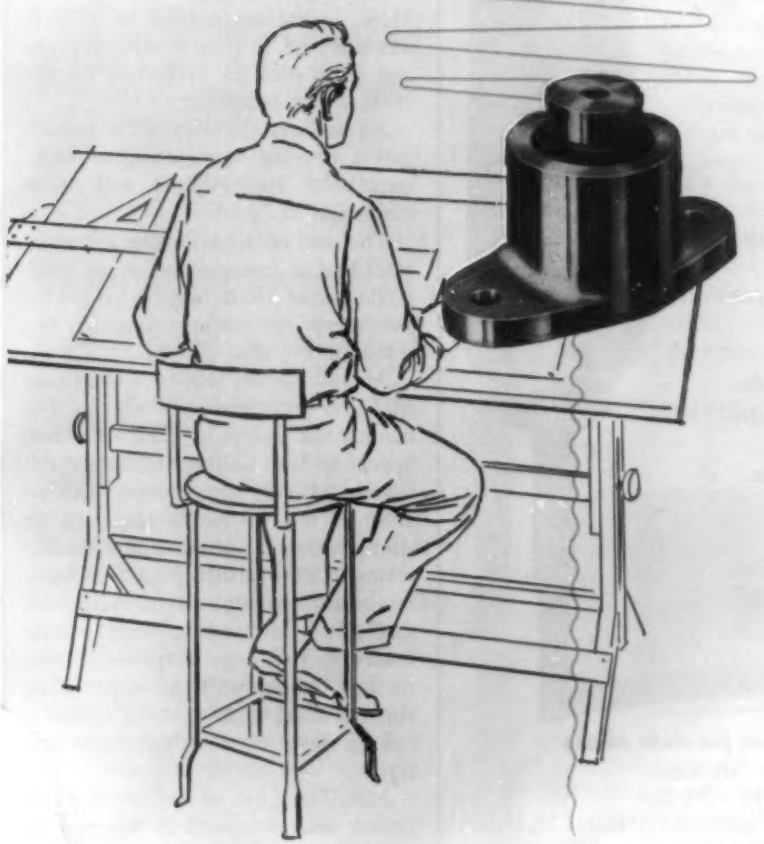


FIG. 5—As designed (A), the lever knob at the end opposite the gate possessed low strength after annealing; some could even be broken by hand. After a number of attempted solutions, the new design (B) proved completely satisfactory.

STOP VIBRATION

right at the drawing board!



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Some Stress-Rupture and Creep Properties of Molybdenum Disilicide In the Range 1600 to 2000 F

Abstracted from "Some Stress-Rupture And Creep Properties Of Molybdenum Disilicide In The Range 1600 to 2000 F," by W. A. Maxwell, Lewis Flight Propulsion Laboratory, Cleveland, Ohio, presented at National Advisory Committee For Aeronautics, Washington, June 24, 1952.

Previous reports have indicated the short-time strength and outstanding oxidation resistance of molybdenum disilicide ($MoSi_2$) at 2000 F and above. The long-time strength of $MoSi_2$ in the range 1600 to 2000 F was surveyed to furnish stress-rupture and creep data for evaluating its use at these high temperatures.

An auxiliary objective of the investigation was the development of techniques for stress-rupture and creep evaluation to 200 F.

The data obtained by the test indicates that at temperatures above 1800 F, the use of $MoSi_2$ may be limited by the creep rate rather than by the stress-rupture life.

At 1800 F the 100-hr strength of $MoSi_2$ is far superior to that of the comparison materials. Creep does not appear to be a limiting factor for the silicide at this temperature. Above 1800 F the silicide is surpassed in strength only by the alumina-chrome cermet. Although the long-time high-temperature strength of molybdenum disilicide is outstanding, there is some evidence that the silicide requires further development to improve its thermal shock characteristics before it can be used as a turbine-blade material.

Metallographic evaluation has revealed several aspects of damage to moblydenum disilicide under prolonged stress at high temperature. Possibly the most noticeable change in the material caused by the evaluation conditions was indicated by the difficulty with which specimens of material which had failed were polished. The untested material was readily polished to a good surface, while a usable surface on the failed specimens was attained only with the greatest difficulty.

An investigation of the stress-rupture and creep properties of hot-pressed molybdenum disilicide has produced the following results:

1. The stress-rupture properties can

be summarized as follows:

Temperature, F	Stress, psi	Time to rupture, hr	Creep rate, in./in./hr
1600	35,000	107	0.000024
1800	20,000	224	.000028
1900	12,000	110	.00073
2000	10,000	85	.0018

2. The use of molybdenum disilicide above 1800 F may be limited by the creep rate rather than by the stress-rupture life.

3. The long-time strength of molybdenum disilicide at high temperatures is superior to that of the high-temperature alloys and titanium carbide ceramals.

4. A comparatively convenient and satisfactory method for creep and stress-rupture testing to 2000 F has been developed.

Control of Residual Stresses in Practice

Abstracted from "Control of Residual Stresses in Practice," by George Sachs, Director of Metallurgical Research, Syracuse University; SAE Golden Anniversary Annual Meeting, January 10-14, 1955, Detroit, Michigan.

In general, methods of controlling residual stresses can be classified as follows: (1) selection of the material; (2) development of processing and heat-treating methods; (3) close control of finishing operations; and (4) application of a final mechanical treatment. These are also called "mechanical-stress relief;" and stress-relief annealing. The most important single factor is that control should be applied earlier as well as during the last stages of production.

The extent of using the various control measures greatly depends upon the particular application, i.e., the nature of the properties responsible for optimum service performance. These properties are either entirely of a mechanical nature, or they are a combination of mechanical and chemical resistance, or they may be such a physical property as dimensional stability during machining operations.

Hydrogen embrittlement and stress-corrosion cracking of aircraft and other steels, heat-treated to high strength levels, is usually controlled by the following two control measures: (1) stress-relief anneal at a temperature

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slightly below the tempering temperature; and (2) mechanical surface treatment consisting of shot-blasting.

Both measures must be applied prior to the exposure to hydrogen. They eliminate failures associated with residual stresses. However, they do not prevent hydrogen embrittlement due to directly-applied loads or residual stresses developed during assembly. The main control measure, in these respects, is heating to 300 to 400 F for several hours to remove the hydrogen. However, full future control of hydrogen embrittlement for aircraft applications must include cleaning and plating procedures. These must either prevent hydrogen embrittlement or result in a permeable coating which renders baking more effective. Furthermore, the danger of embrittlement greatly increases with strength. Therefore, selection of a steel with lower strength may be the only effective measure of avoiding such failures, in extreme cases.

The best-known example of stress-corrosion cracking is the "season cracking" of brass and copper-alloy parts which were subject to drawing or spinning. Similar phenomena also are encountered in carbon and low-alloy steels, stainless steels, and aluminum alloys. To eliminate season cracking usually a stress-relief anneal is applied, which eliminates most of the stresses and the cracking without reducing the hardness. However, cracking cannot always be eliminated or prevented by this measure, as, for example, the cracking of cartridge cases on firing or in storage.

The cracking of simpler shapes, such as wire, rod and tube, frequently can be controlled by mechanical finishing operations, such as stretching or compressing. Bending and a straightening process, called "reeling" or "polishing", convert tensile stresses into compressive stresses.

However, in the case of tube and wire the most effective measures are applied during production. These include proper selection of tool contour and reductions and are particularly effective for brass tube where the right combination of wall and diameter reduction produces very little stress and eliminates the danger of cracking.

Occasionally, none of the above measures are fully effective. It then may become necessary to change to a material with less tendency to crack-

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⅜	½ 1¼	9 18	⅜ M-10 ⅜ M-20	1000	700
½	½ 1¼	10 20	½ M-10 ½ M-20	750	525
¾	½ 1¼	11 22	¾ M-10 ¾ M-20	600	425
1	½ 1¼	12 24	1 M-10 1 M-20	550	375
1¼	½ 1¼	13 26	1¼ M-10 1¼ M-20	300	200
1½	½ 1¼	14 28	1½ M-10 1½ M-20	275	175
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ing. In the case of austenitic stainless steels, a stabilizing treatment which changes the structure of the alloy is known to be beneficial in this respect.

In general, the question of whether residual stresses affect fatigue strength is still not completely answered. Undoubtedly, they are of importance. However, the effect is small for uniform, polished sections. In contrast, residual stresses introduced into a reduced section by plastic deformation noticeably affect the fatigue strength. This applies both to direct effects of stretching or compressing and to the indirect effects of localized heating.

The direct effect of tension stresses, however, is rarely observed in practical service. Fatigue failures which are attributable directly or predominantly to residual tensile stresses have only occasionally been reported.

Compressive stresses, on the other hand, are associated with mechanical measures which increase the life of high-strength steel parts. Such finishing treatments are shot peening and surface rolling.

Residual stresses developed in conventionally machined and ground parts also affect the fatigue properties. As far as machining is concerned, this effect is probably insignificant in most instances. It even may be beneficial, as dull tools act much the same way as surface rolling and produce compressive stresses.

Grinding, on the contrary, can be harmful as it heats the surface and develops tensile stresses. It may also cause checking and cracking but its control appears to be a difficult shop problem. With heat-treated, high-strength steels a regular check of surface hardness should be used to prevent damage. Etching has been used to disclose excessive stresses.

Basic Conflicts in Engineering Education

Abstracted from "Basic Conflicts in Engineering Education," by Arthur Bronwell, Secretary of the American Society for Engineering Education, *Mechanical World*, November 1954.

Four movements have altered the basic framework of engineering education over the last 25 years. Greater emphasis has been given the mathematics and basic sciences. Development of special technological areas have intro-

duced new concepts and methods of analysis. More importance has been attached to the humanities and social sciences. Less time is devoted to skills and techniques, such as shop work and drawing.

Today educators are being urged to consider the fields of solid-state and nuclear physics. Also demanding study are expanding fields that include combustion, vibration analysis, elasticity and fluid mechanics.

Educators must determine what is fundamental and essential, how to organize material in orderly sequence, and how material can be integrated with other engineering knowledge.

Mathematics is receiving increasing emphasis for functional and conceptual utility. It serves as a tool of analysis and design and gives the engineer insight into physical processes at work. But many engineers and educators oppose the inclusion of further scientific and mathematical material in the undergraduate curriculum. This group favors the stressing of engineering practices.

The ASEE Committee on Evaluation of Engineering Education recommends that primary emphasis be devoted to the science of engineering. Industry, it is said, is better equipped to teach engineering practice.

Some educators hold that there should be a single monolithic undergraduate curriculum, to provide the student with a broader engineering base than present specialized curricula offers. It is contended that division of material into a variety of engineering fields is artificial and that the engineering should have a general basic knowledge to cope with a diversity of situations. Opponents of a monolithic system cite the likely rigidity of subject matter under such a system, which would inhibit growth of new ideas.

It has been suggested that engineering education may be improved by establishing greater unity in mathematical methods. In one plan unification would spring from certain fundamental properties common to all fields. In another, similarity of mathematical methods as applied to various fields would be demonstrated. But those opposed to the unified approach claim students learn best by proceeding from specific case to the general, that each field of application is best developed from its own concepts.

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in the engineering curriculum. What are the possibilities to consolidate all material on one subject into one course? How essential is repetition to proper understanding of subject matter?

An area of conflict concerns the administration of courses in the social sciences and humanities. Should emphasis be placed on courses of a fundamental nature, to convey the fundamentals of supervisory or managerial work? Or should emphasis be placed on the arts, philosophy and history, for cultural and spiritual development?

Disagreement exists on the length of the undergraduate program. The proponents of five-year curricula characterize their graduate as better prepared in the fundamental sciences, his area of specialization, and in cultural studies. Supporters of the four-year program claim the formal educational program should be limited to that necessary for an adequate foundation, and that the graduate courses fill the needs of advanced study.

Other problems confronting the educator and engineer—1) Assuring development of the reasoning processes in face of increasingly compressed studies; 2) how to develop genuine creative thinking; 3) the education of gifted students.

Residual Stresses— How Dangerous Are They?

Abstracted from "Residual Stresses—How Dangerous Are They?," by Walter Soete, Prof. of Welding, University of Ghent, Belgium, *Metal Progress*, January 1955.

To review and summarize what is known about residual stress, the author finds it necessary to examine basic definitions of stresses and how they act in various types of structures.

He points out experiences both here and abroad with the effects of residual stresses on brittle fractures concluding that, in sound structures, residual stresses to help propagate brittle fracture at low temperature.

Other conditions are: (1) during static loading of a sound structure, residual stresses have an influence on the yield point, but not on the ultimate strength; (2) the fatigue strength of a sound structure is not affected by residual stresses; (3) during static loading of a structure with faults

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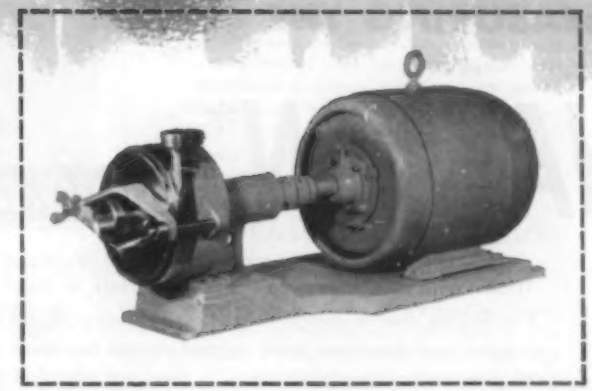

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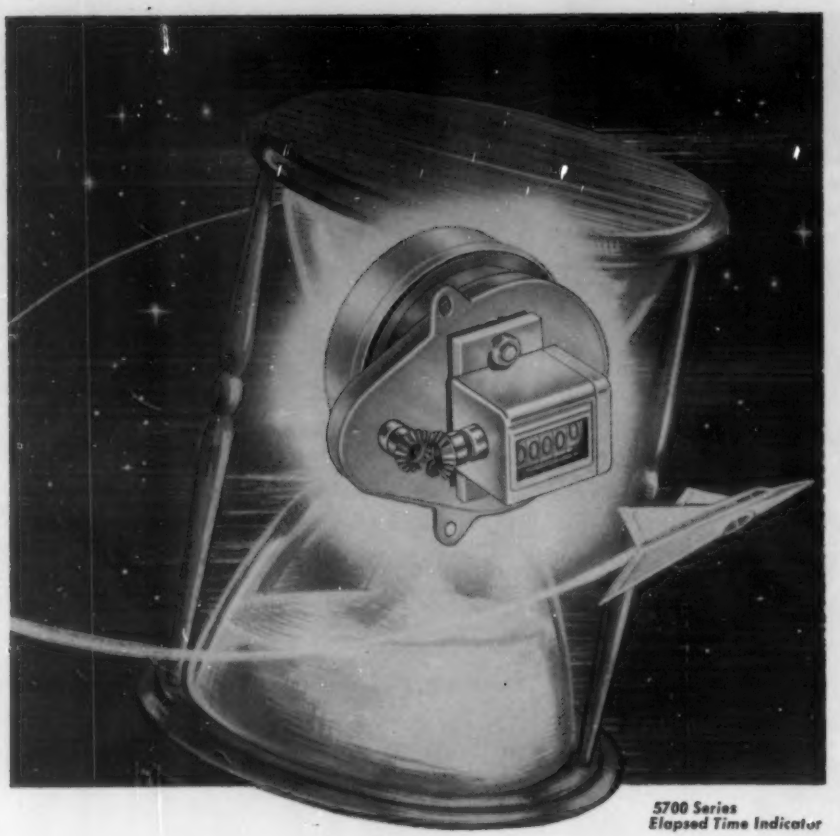

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(cracks or notches), residual stresses influence the fracture appearance if the temperature is below a critical value; (4) the influence of residual stresses on fatigue strength of a structure in which there are faults is masked by their effect as notches; (5) the role of residual stresses on elastic stability is not known; and (6) residual stresses are known to increase the tendency to corrosion.

Machine Tool Automation

Abstracted from "Machine Tool Automation," by K. O. Tech, Ch. Engr., the Cross Co. Presented at the joint session of the Machine Design and Production Engineering Divisions, the Annual Meeting, ASME, New York, N. Y., Nov. 28 to Dec. 3, 1954.

The machinery tool industry has developed first, single and then multiple station machines, such as turret lathes, automatic screw machines, and finally transfer machines which combine more and more machining operations into a single unit. This made necessary machines with provisions for automatic locating, automatic clamping, automatic cutting cycles and automatic material handling and today the automatic factory is in sight.

The success of the automatic factory will depend in a large measure upon control of the down time, and in this down time is the practical limit of automatic factory efficiency. There are two classifications of downtime: the first is that required to carry out such tasks as changing tools, cleaning the machine. Tool programming becomes an important factor and the need for automatic tool programming stems from the fact that tools which were once under close personal observation are now removed from this attention. Because of the inconsistency of tool performance and other variables the first requirement of a tool programming device is flexibility.

Over-all or master programming of all tools in a machine is impractical. The solution is automatic programming for each tool, and can be obtained by using a device which counts the number of operations a tool performs while it is working in the machine. After the tool completes the required number of operations, the programming device then shuts the machine down for a change. Such in-

dividual programming does not reduce downtime, but provides the basic programming unit that can be used along with other instrumentation to keep tool-changing downtime within specified limits.

A second type of downtime is unpredictable and generally results from breakdowns. This can, in practice, be almost entirely eliminated by proper design. This design must consider a number of important factors.

Chips are a continual problem in transfer machines, and they must be carried away from the machine continually, and without interfering with the operation.

The cooling system is another important item, and for efficient operation it is necessary that the coolant be supplied to proper points. The buildup of chips must not be allowed to interfere with the proper coolant flow. Guards to retain the coolant within the machine must also be used, since the coolant is often harmful to both electrical equipment and operator.

Once a breakdown occurs on a machine, it is important that the machine be put back into production as soon as possible. Proper tagging and identification of limit switches and control valves should be made, not only by number, but also by function. Compartments on a machine should be tagged to indicate whether or not they are electrical raceways or contain mechanical components. All wire should be adequately identified so tracing of circuits can easily be effected.

How to Determine Assembly Tolerances

Abstracted from "How to Determine Assembly Tolerances," by Martin H. Saltz, Quality Control Engr., Hughes Aircraft Co., Culver City, Calif., *The Tool Engineer*, Feb. 1955.

By employing the statistical considerations of quality controls, it is possible to determine tolerances on a more exact basis so that they will be as loose as possible and still satisfy the specifications.

However, it is first necessary for the process or processes producing the parts to be in statistical control. One of the tools commonly used for this purpose is the sensitive X and R

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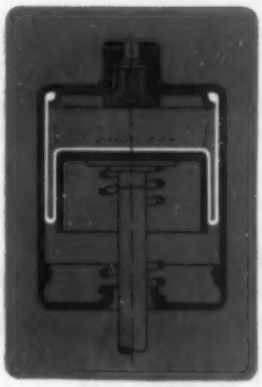

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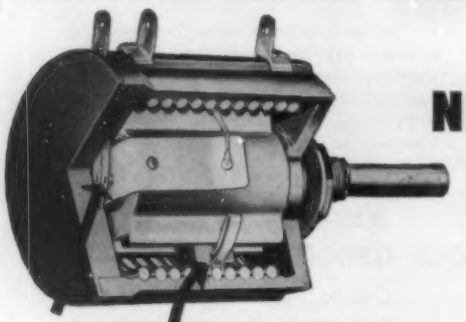

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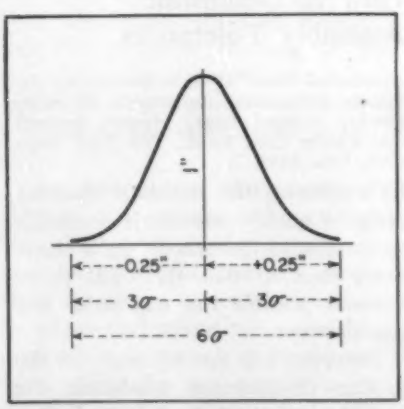
chart. The method can be readily understood by considering as an example a simple assembly consisting of three rods being placed end to end. Rod A is 1 in. long, ±0.25 in.; rod B is 2 in. long, ±0.25 in.; rod C is 3 in. long, ±0.25 in. By assembling the smallest of parts, the assembly's total length would be 5.25 in. If however, the longest of parts are assembled, the assembly would be 6.75 in. Superficially it would seem that the tolerance of the assembly should be 6 in., ±0.75 in. This assumes that the minimum of each part will always mate with the minimum of the other component, similarly, that the maximum will always be mated with the maximum of the other components. Many firms follow this type of reasoning in assigning tolerances to assemblies.

In the example just cited, if the desired length of the overall assembly were 6 in., ±0.75 in., and the tolerance of each component were to be equal, under present procedures, tolerances of ±0.25 in. would be assigned to each of the components. As will be seen shortly, the 0.25 in. is over-severe.

If parts are taken from a process in statistical control, which is producing part A, and grouped according to their length, the resulting histogram can be represented by a smooth curve, shown below. The nominal value would be 1 in. and the natural tolerances would be ±0.25 in. Of the parts produced by this process 99.7 per cent would fall within plus or minus three sigma (σ) or a total spread of six sigma, where sigma is a measure of the spread of a distribution and is



DISTRIBUTION OF PARTS produced to a specification of 1 in., ± 0.25. As indicated, the total tolerance is equal to six.

equal to the root mean square deviation of the measured values from the average. Then one sigma for this process would be 0.5 in., divided by 6 and equal to 0.083 in. Similarly, sigma for parts *B* and *C* would be equal to 0.083 in.

It can be shown that sigma for the assembly (σ_T) would be equal to:

$$\begin{aligned}\sigma_T &= \sqrt{S_a^2 + S_b^2 + S_c^2} \\ &= \sqrt{(0.083)^2 + (0.083)^2 + (0.083)^2} \\ &= 0.083\ \sqrt{3} \\ &= 0.144 \text{ in.} \qquad (1)\end{aligned}$$

and six sigma for the assembly would be equal to 0.864 in. Thus, the tolerances on the completed assembly are ±0.432 in., instead of ±0.75 in. as previously assumed.

In practice, it is usually desired to determine the tolerances to be applied to components so that the resulting assembly tolerances will be within a particular value. This, in effect, is the reverse of the procedure just demonstrated.

The procedure then is as follows: based on the same assembly, it is assumed that the desired overall length is to be 6 in., ±0.75 in. The question is: what tolerance should be assigned to the individual component values so that the requirement on the assembly will be met? If these tolerances were assigned on a visual basis the answer to the problem would be ±0.25 in. Solving by statistical methods will demonstrate that a saving can be realized.

It can be reasonably assumed that the tolerances of the individual parts are the same, therefore, the sigma value for the assembly is 1.50/6 which is equal to:

$$\sigma_T = \sqrt{S_a^2 + S_b^2 + S_c^2}$$

Solving for $S_a + S_b + S_c$ the result is 0.144 in.; therefore, the tolerance on each component of the assembly is equal to $\pm 3 \times 0.144 = \pm 0.432$ in. If the tolerances, and therefore sigma for each component are the same, this equation simplifies to:

$$\begin{aligned}\sigma_T &= \sigma\sqrt{3} = 1.73\,\sigma \\ 1.73\sigma &= 0.25 \text{ in.} \\ \sigma &= 0.144 \text{ in.} \\ 3\sigma &= 0.432 \text{ in.}\end{aligned}$$

Although the text has been restricted to the lengths of components of assemblies, the same procedure can be applied to resistance in series, weights or any other characteristics.

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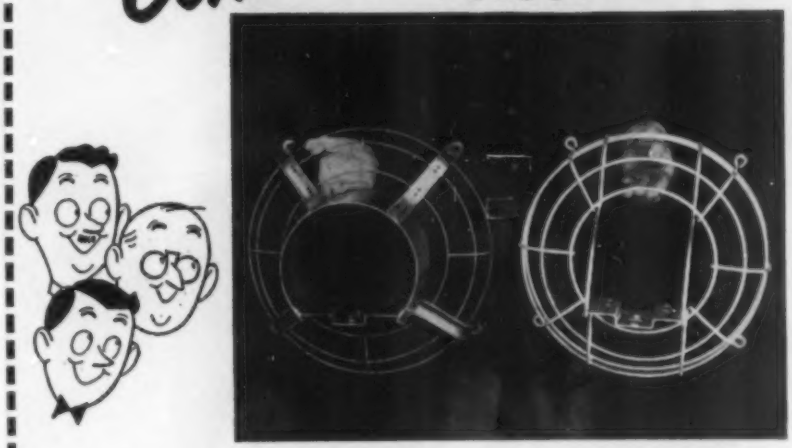

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Introduction to Theoretical Mechanics

ROBERT A. BECKER, *Ph.D., Associate Professor of Physics, University of Illinois.* 6½ x 9½ *in., 420 pp. Published by McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y.* $8.

Written for physics majors and graduate students, this text provides a thorough introduction to classical mechanics. Although the methods of vectors are employed rather extensively throughout the book, no previous preparation is required since an introduction to vector analysis is presented in the first chapter. In addition, the appendix includes some of the fundamentals of differential equations.

The arrangement is such that the topics are presented in the order of increasing difficulty and subjects such as accelerated coordinate systems, the motion of a body with a variable mass, Lagrangian methods and vibrating systems are found in the latter part of the book.

The solution of problems is emphasized throughout the book and although some of the 400-odd problems are rather difficult, there are many which are worked out with the inclusion of both mathematical and analytical discussions.

Industrial Design in America

Edited by the Society of Industrial Designers. 8½ x 11 in., over 224 pages. Published by Farrar Straus and Young, Inc., 101 Fifth Ave., New York 3, N. Y. $12.50.

A selection of the new products designed by 153 members of the Society of Industrial Designers, representing "a significant cross-section of the various types of work done in the field of industrial design for production in 1954." Range and character of products displayed in this showcase rather well supports a 3-page opening statement by A. A. Houghton, president of Steuben Glass, Inc., "In our modern industrial society, it is the professional

designer who increasingly is determining the appearance of our physical environment." He then proceeds to raise some searching questions and closes his introduction with, "Let us be careful that we do not trade spiritual values for material values."

Then, in 200 pages divided in 10 sections (not too logically arranged from an engineer's viewpoint) these selected new products are pictured, with brief copy for each one giving, more or less specifically, the objectives behind the design and the name of the designer. Most, but not all, are products in the field of *Product Engineering*—appliances, business machines, instruments, portable tools, radios, home movie equipment, etc. Other examples—furniture, architectural, ceramics, housewares are generally interesting even if outside our field. One section showing effective use of color (in full-color illustrations) is almost entirely engineered products.

The book itself is a good example of appearance design. Photographs are uniformly excellent; pages are 8½ x 11 in., printed expertly on good paper; book is handsomely bound.

More detailed information as to specific objectives, problems faced, and how answers were found would have made the text of more value to design engineers.

Symposium on Effect of Temperature On The Brittle Behavior of Metals With Particular Reference To Low Temperatures

ASTM Special Technical Publication No. 158, 6 x 9 in., 474 pp. Published by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. $7.50.

The papers and discussions in this symposium were presented at the First, Second, Third, Fifth and Sixth Sessions of the Fifty-sixth Annual Meeting of the American Society for Testing Materials, held in Atlantic City, N. J., June 28-30, 1953.

This symposium was sponsored by the low temperature panel of the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals, and should prove useful to designers, engineers and metallur-

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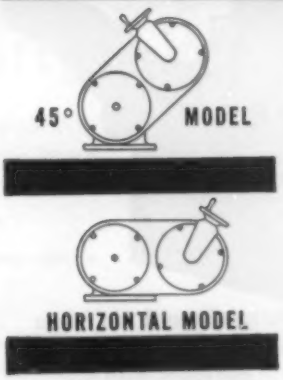

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gists because the papers deal with the joint role played by metallurgical and mechanical factors and their influence on the brittle behavior of metals at low temperatures.

In this symposium, the treatment of structural carbon steel receives more attention than other metallic materials. The phenomena of brittle fracture is explored and discussed as well as the variable response to variations in stress systems, strain rates and size effects. The book includes papers on the significance and reliability of notch toughness tests and certain aspects of current research on these subjects.

New data on titanium, quenched and tempered steels at high strength levels, and several types of cast irons should help design engineers in the development of a new approach and understanding of design criteria.

Bibliography on Unionization Of Professional Engineers

Engineering Societies Library. 8½ x 11 *in.*, 8 *pp. Published by Engineering Societies Library,* 28 *W.* 39 *St., New York* 18, *N. Y.* $2.

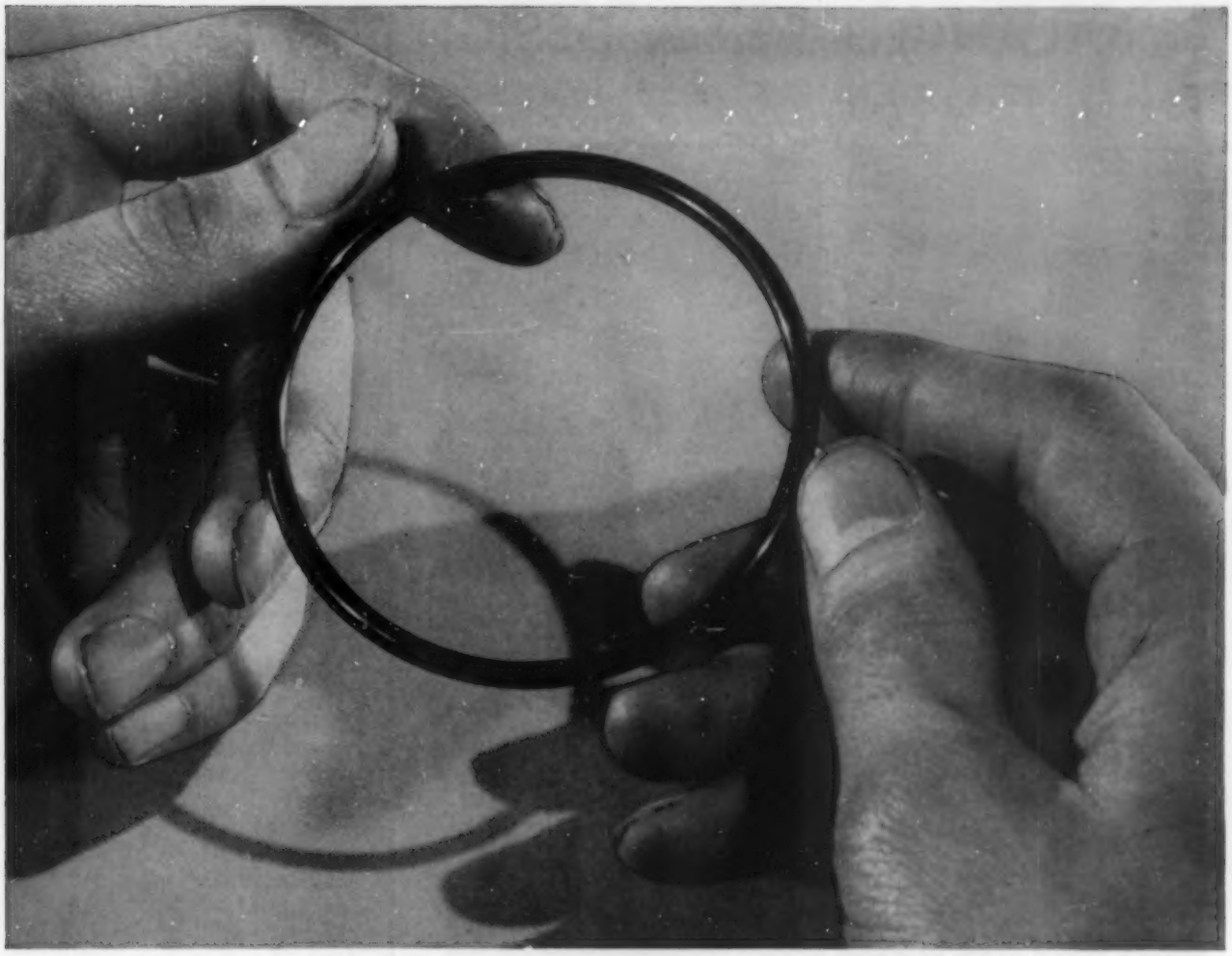
This list of references was prepared to answer inquiries received by the Library from engineers and engineering students. The 100 references included are to publications dating from 1937 to 1944 which are now available in the Library. Many viewpoints on the question are represented.

Magnetic Control of Industrial Motors

GERHART W. HEUMANN, *Industry Control Dept., General Electric Co.* 6 x 9 *in.*, 714 *pp. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York, N. Y.* $9.50.

During the years since the first edition of this book appeared, the industrial control industry has enjoyed vigorous growth. The increasing demand for engineers trained in the control art has brought about an increasing demand for training facilities, and an increasing number of schools are offering courses on design and application of industrial control apparatus.

Large numbers of papers and trade magazine articles appear every year, reporting on continual progress in an



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industrial field that obviously has not yet reached the knee of its growth curve. The large amount of technical literature appearing every year on control subjects proves the great interest that exists in these subjects on the parts of users and designers of control apparatus.

Many changes have taken place in the design of control components and systems since the first edition of this book was written. This second edition brings the book up to date and reflects the recent progress that has been made in the electrical art. Those chapters touching upon feedback or closed-cycle control systems have been expanded. However, because of the complexity and variety of feedback control systems in actual use, the student interested in a thorough analysis of such systems should consult a textbook devoted exclusively to that subject.

Increasing complexity of industrial drives and changes in design of components are responsible for numerous changes in industrial practices that have resulted in changes in industrial standards, especially in NEMA Standards for Industrial Control. All statements, tables, and diagrams conform to the latest industrial standards.

As an aid to teaching industrial control subjects, problems have been added to many chapters. These problems have been modeled on those with which practicing engineers are confronted in their day-to-day design and application work.

Tables of Integral Transforms

Edited by A. Erdelyi, *Professor of Mathematics, California Institute of Technology, and sponsored by that Institute as part of the Bateman Project, Vol. II, 9¼ x 6½ in., 450 pp. Published by the McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y. $8.*

The Bateman project consists of five books: three volumes titled "Higher Transcendental Functions," and two supplementary volumes, "Tables of Integral Transforms." This project was originally conceived by the late Professor Harry Bateman, of the California Institute of Technology. After his death in 1946, the Institute, with the financial support of the Office of Naval Research, assumed re-

sponsibility for carrying out Bateman's plans. This is the second of two volumes of tables of integrals involving higher transcendental functions, and is designed for the use of mathematicians, physicists and engineers. Together, the two volumes contain tables of all integral transforms frequently used in pure and applied mathematics and engineering.

This volume contains Hankel transforms of which the kernal is a Bessel function; fractional integrals; Stieltjes; and Hilbert transforms; and a collection of integrals of higher transcendental functions.

This is the first-known work in which the collection of known integrals involving these higher transcendental functions is undertaken on a large scale. It is only work containing tables of all important transforms, and the only work tabulating fractional integrals, Hankel transforms and other Bessel transforms, all of which have not been tabulated hitherto on an extensive scale. Some results included in the tables have been extracted from standard literature. Others have been taken from sources which were not readily accessible, and many of them are entirely new. The work is so planned that the practical mathematician, the physicist or the engineer can evaluate integrals with a minimum of labor.

Although this work is prepared to be used with "Higher Transcendental Functions," each volume of the tables may be used separately. All notations are explained in an appendix, making the user independent.

International Journal of Abstracts on Statistical Methods In Industry

General Editor, GRANT I. BUTTERBAUGH. 6 x 9 *in.*, 79 *pp*, *paper-bound. Published by the International Statistical Institute, 2 Oostduinlaan, The Hague, Netherlands*, $1 (postage included).

Although the title suggests a grouping of abstracts, the journal contains a short description of the articles rather than a condensation. However, it is a fairly complete survey of statistical methods that includes many foreign sources such as French and Japanese. The descriptions of the

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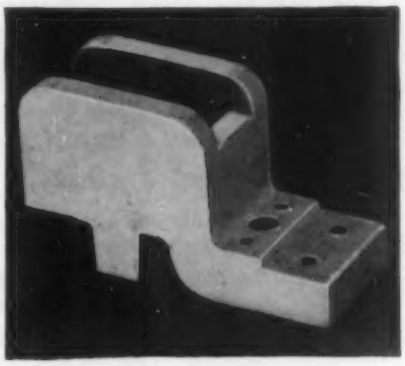

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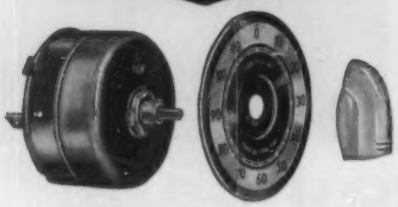

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French articles would have been more rewarding to the uninitiated if they were translated into English.

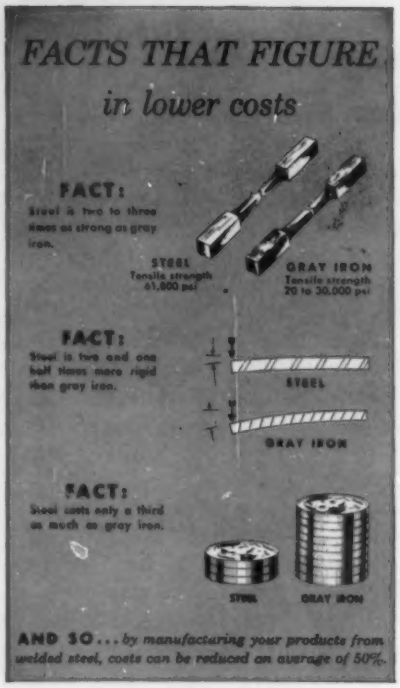
The 120 articles are classified under five major categories: Process Control; Sampling and Acceptance; Research and Development; Administrative Applications and Operations Research; and Management Applications.

Symposium on Temperature Stability of Electrical Insulating Materials

6 x 9 in., heavy paper cover, 141 pp. Published by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. $2.75.

Insulating materials have long been divided into several temperature classes based to a large extent on a broad definition of their composition—that is, organic, inorganic, combinations of organic and inorganic. Service experience has served generally to confirm the classifications and to establish the suggested temperature limits for each class. In view of the rapid development of new insulating materials in recent years, it has become increasingly apparent that test methods and standards are necessary as guides for determining the thermal stability of insulating materials. This symposium is an important part of such effort. Sponsored by ASTM Committee D-9 on Electrical Insulating Materials, this symposium was presented at the 57th Annual Meeting of the ASTM held in Chicago in June, 1954.

Eleven papers are included in this symposium. The titles and authors are: "Measurements of Dielectric Propties of Temperatures up to 500 C," A. H. Scott, P. Ehrlich and J. F. Richardson, National Bureau of Standards; "Dielectric Measurements on Plastics at High Temperatures," Thomas Hazen, Bakelite Corp.; "Thermal Stability of Insulating Fabrics," R. C. Bartlett, Natvar Corp.; "Electrical Properties of Thermosetting Plastics at Elevated Temperatures," R. R. Winans and W. Hand, New York Naval Shipyard; "Thermal Stability of Polyvinyl Chloride Insulating Compounds," R. C. Bartlett, Natvar Corp.; "The Deflected Beam Film Rupture Test Applied to Sheet Insulation," K. N. Mathes and H. I. Morgan, General Electric Co.; "Electrical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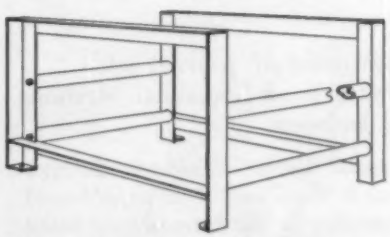

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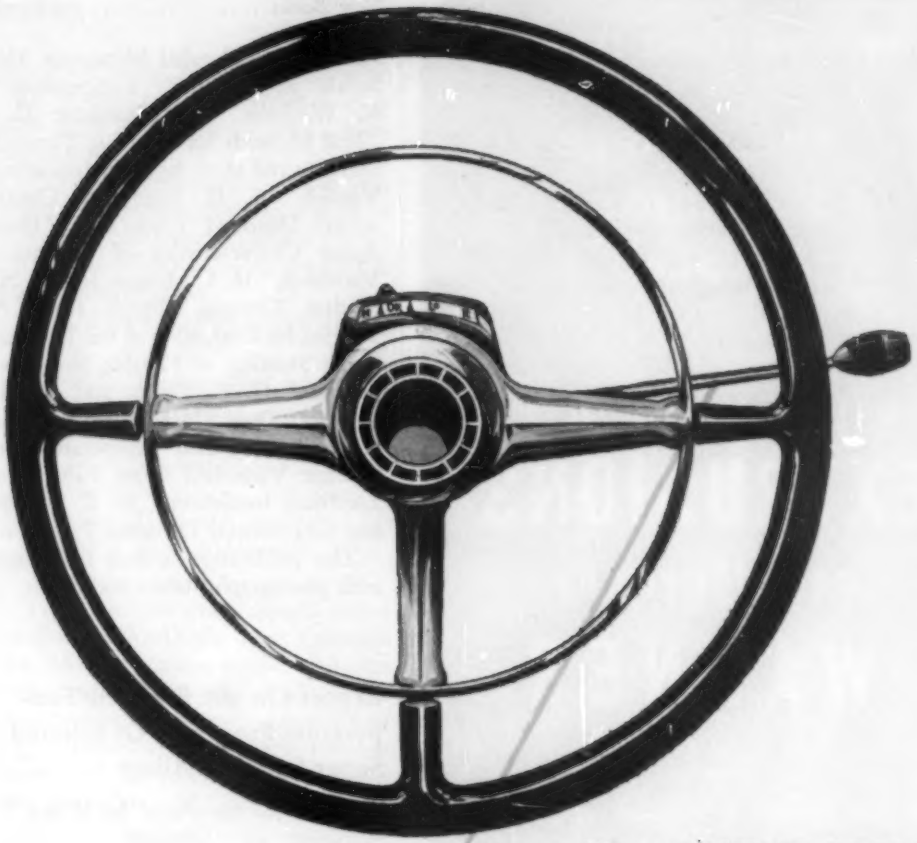

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The performance of these forged ring gears is also far superior to the sand cast gear, which had a tendency to flake away and crack around the teeth, causing failures. More than five million forged ring gears have now been used in these transmissions without a single failure. Being porous, the sand casting was difficult to balance, but the forging has a dense, homogeneous structure that helps keep it in perfect balance.

Strong, long-wearing non-ferrous metal parts, forged to your specifications by Mueller Brass Co., can help reduce your costs and improve the performance of your products just as they have done in this transmission application. For complete information, write us today.

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Resistivity of Bonded Micaceous Materials at Elevated Temperature," K. Wechsler, Mica Insulator Co.; "Test Methods for Studying Thermal Stability and Heat Aging of Insulating Varnish," A. H. Haroldsen, Continental Diamond Fibre Co.; "Heat Aging Characteristics of Insulating Varnishes," H. I. Morgan and K. N. Mathes, General Electric Co.; "A Method for Evaluation of the Thermal Aging Stability of Flexible Sheet Insulation," C. G. Currin and R. M. Plettner, Dow Corning Corp.; and "Effect of Elevated Temperature on Silicone Varnished Glass Fabric for Electrical Insulation," O. E. Anderson, Continental Diamond Fibre Co.

The publication is well illustrated with photographs, tables and charts.

Report On the Elevated-Temperature Properties Of Selected Super-Strength Alloys

Prepared for the Panel by WARD F. SIMMONS *and* HOWARD C. CROSS. *Special Technical Publication No.* 160, 8½ x 11 *in.*, 208 *pp. Published by the American Society For Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.* $4.75.

This is the third in a current series of reports prepared under the auspices of the Data and Publications Panel of the ASTM-ASME Joint Committee on the Effect of Temperature on the Properties of Metals. This report is a summary of the elevated-temperature strength data for 13 selected super-strength alloys. Included are 116 summary curves showing tensile strength: 0.2 per cent offset yield strength; per cent elongation and reduction of area; stresses for rupture in 100, 1,000, 10,000 and 100,000 hr when available; and stresses for creep rates of 1 per cent in 10,000 and 100,000 hr.

A total of 206 data sheets appear in the body of the report. A brief description of each alloy is included which gives chemical composition, recommended heat treatment, and a few words about forging and machining. These alloy descriptions furnish the reader with a basis of comparison so that he can refer to the optimum processing conditions recommended by the producer of each alloy when using the data. Apparently it is not intended that these brief descriptions serve as a

guide for using the alloys in production, as complete information is available from the alloy producers upon request.

The Appendix contains some very short-time rupture data for several of the alloys, and a compilation of chemical compositions for approximately 100 super-strength alloys.

The following alloys are covered by the data:

19-9DL	Haynes Alloy No. 25
16-25-6	Refractaloy 26
Discaloy	
24	Inconel "X"
A-286	M-252
N-155	Haynes Alloy No. 21
S-590	Haynes Alloy No. 31
S-816	

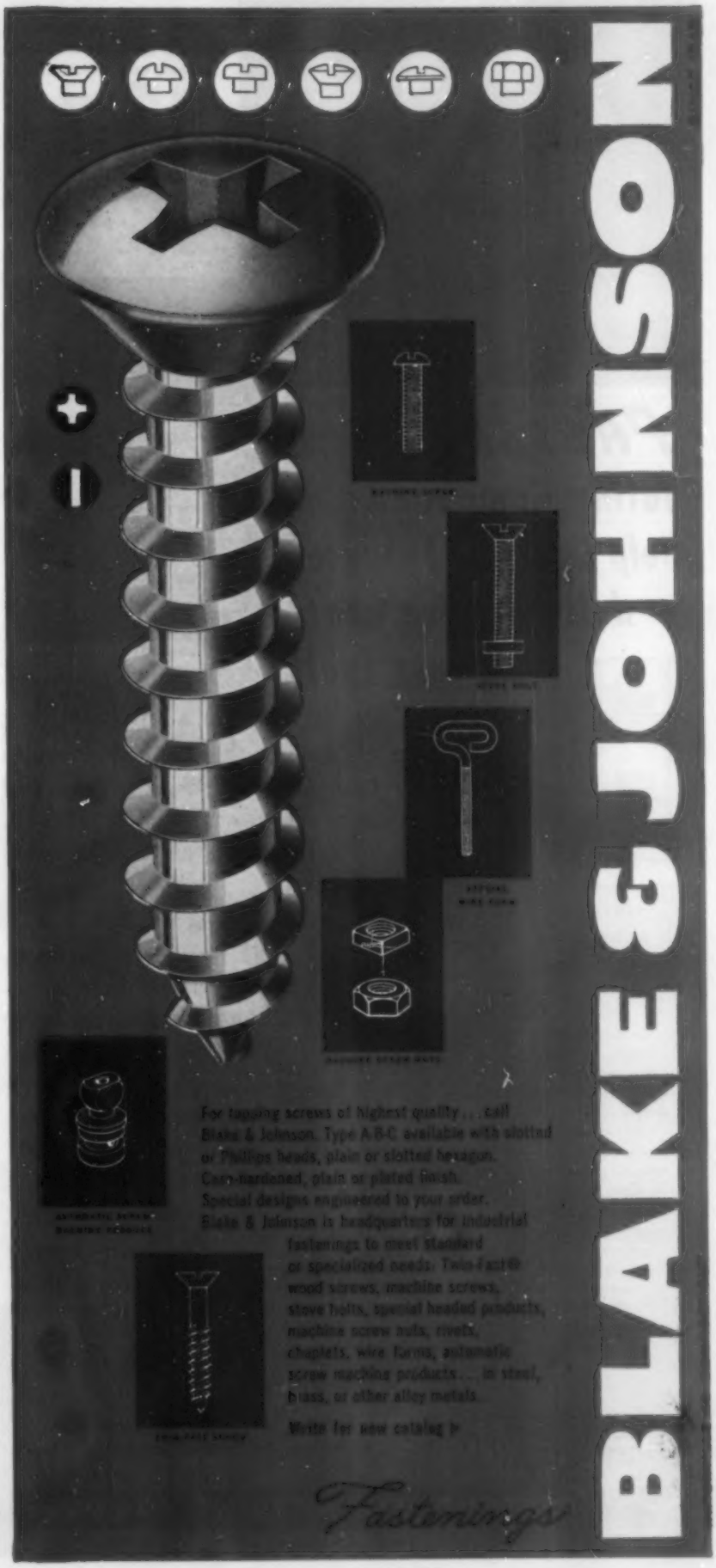
There are two other reports issued by the ASTM-ASME Joint Committee which supplement the information contained in this third report. The first report covered a number of the commercially produced stainless steels and the second report covered the chromium-moly steels. All three reports are designed as graphical summaries of the available high-temperature data and its effect on properties.

Abstracts of the Literature on Semi-Conducting And Luminescent Materials

Battelle Memorial Institute, Columbus, Ohio; sponsored by the Electrochemical Society, Inc. 9 x 11 in., 169 pp. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. $5.

Special attention has been given in recent years to semiconducting and luminescent materials. Because of the many and somewhat distantly related types of scientific and engineering efforts in developing the utilization of elements such as carbon, germanium, silicon, tin, selenium, tellurium, phosphorus, and inorganic compounds such as oxides, selenides, tellurides, antimonides, arsenides, phosphides, halides, published matter is appearing in more than 50 publications throughout the world.

To fill the need for an organized collection of abstracts of literature on semiconducting and luminescent materials and their applications, the Solid State Devices Div. of Battelle Memorial Institute developed an annual collection of abstracts covering this



• • Elastic tape, extruded in beads, ribbons and tailored shapes, gains adhesion with aging.

Spotweld sealer on blower chute assembly remains soft and tight at high or low temperatures.

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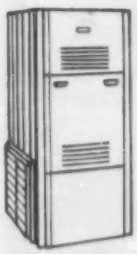
Sealing Compounds help Coleman Furnaces deliver more heat with less fuel!



To prevent costly casing leaks of heated air, which would reduce heating efficiency and increase fuel consumption, Coleman's famous Blend-Air furnaces are *sealed air-tight* with Presstite spotweld sealers and elastic tapes.

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Over 400 Presstite sealants protect against dust, dirt, air and water in thousands of sealing applications. Write today to learn how Presstite can meet your sealing needs, *whatever* they may be.

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field. The publication of abstracts compiled are sponsored by the American Electrochemical Society.

This bibliography covers literature published from Jan. 1 to Dec. 1, 1953. The principal source of references have been the abstract journals, although in some cases the entire publication has been reviewed. A bibliography format was chosen as the most convenient for those who wish to use it as a desk reference. Subject and author indexes are included to aid finding material.

The general headings of topics are: germanium, silicon, carbon and diamond, boron, gray tin, antimony, and phosphorous, selenium and tellurium, selenides and tellurides, borides, carbides, nitrides, and silicides, oxides, phosphates, silicates and others, sulfides, halides, organics, luminescence and phosphorescence, semiconductor theory. In all cases applications are a subheading under material concerned.

Electrical and Electronic Apparatus

10¼ x 8 in., Order No. 111468. *Available from Office of Technical Services, U. S. Dept. of Commerce, Room 6227, Washington 25, D. C.* $4.

This book is one of a series of publications designed to disseminate information concerning the patented inventions owned by the Government and to stimulate greater utilization of these inventions. These inventions are ordinarily available on a royalty-free basis.

Described in this book are 1,915 inventions applicable to the electrical and electronic apparatus industry, covered by patents active as of Dec. 31, 1953. For each invention, the name of the inventor, the name of the government agency administering the patent, and an abstract of the patent or the invention are given. Evaluation of the invention with respect to its industrial application is facilitated by an examination of the technical data contained in the abstract.

The following classifications are included: wiring devices and supplies; measuring instruments; particle accelerators; motors and generators; controls and switches; heating, pumping and welding apparatus; lamps; radio and related object-located and navigation apparatus; electron tubes; computing apparatus; telephone and telegraph equipment; batteries; X-ray apparatus.

OUR READERS SAY . . . . . .

Letters should be addressed to The Editor, *Product Engineering*, 330 West 42nd St., New York 36, N. Y.

Thin-wall Cylinder Strength

To the Editor:

In your October, 1954, issue are published charts for designing cylinders. I have carefully examined Case I referring to cylinder strength in torsion and discovered that there were omitted stress corrections depending on length ÷ outside diameter ratio. This question has been discussed in the June, 1951, issue of *Steel Processing* and the formula establishing value of stress correction factor μ was published.

This formula is: $\mu = 1.389\ (1 - 0.1277\ \frac{X}{1.185^2})$, in which $X = \frac{L}{D}$ With $\frac{L}{D} = 4, 3, 2, 1$ is $\mu = 1.05, 1.10, 1.15, 1.25$, respectively. Applying the above formula to the numerical example published on pp 184 of *Product Engineering*, we obtain corrected value of torque: $\frac{L}{D} = \frac{40}{10} = 4$, $Q = 5 \times 10^5 \times 1.05 = 525{,}000$ in-lb, as against 500,000 in-lb as established by the contributor. —VICTOR TATORINOV

Consulting Engineer
Prague, Czechoslovakia

What Makes It "Put-Put?"

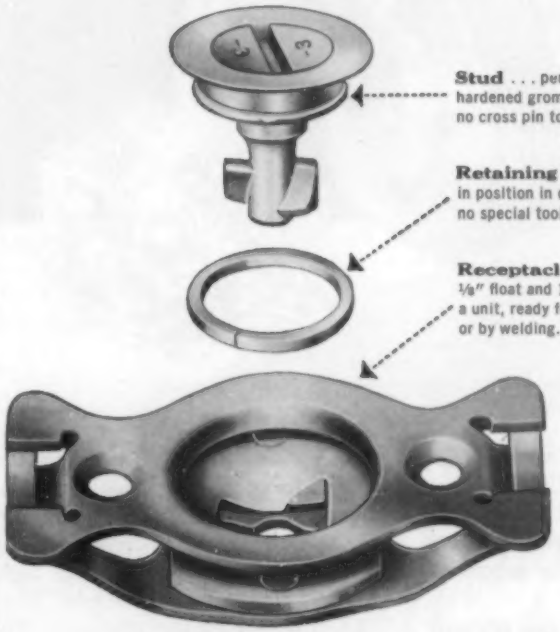
To the Editor:

Some time ago, one of my small sons received a gift of a small toy motorboat. It was made in Japan of sheet metal and contained a small, thin-walled brass chamber connected by two narrow brass tubes to the stern. To operate it, one introduced an eye-dropper of water into the brass chamber via either one of the brass tubes and placed a small lighted candle under the brass chamber. In a short time a "put-put" of steam impulses issues from the stern tubes and sends the boat moving rapidly about a tub or pond.

Recently, as an outgrowth of a

New "Style 3" Panel Fastener!

PANELOC introduces Light-Weight, All-Steel Model, Setting Superior Standards in Tension and Shear at a new low price! Only three simple parts to inventory.



Stud . . . permanently assembled to a hardened grommet, comes as one unit, no cross pin to loosen or fall out.

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Receptacle . . . all steel, with full 1/8" float and 1" rivet spacing. Comes as a unit, ready for mounting with two rivets or by welding.

Exceptional durability, low price, and simplicity make the new fastener a newsworthy item. It conforms to Specification MIL-F-5591A and is interchangeable with all other "Style 3" fasteners. Let us send you a detailed catalog on the lightest, strongest, most economical "Style 3" Fastener available today.

PANELOC...America's most versatile line of aircraft fasteners...includes Styles 1, 2 and 3 Panel Fasteners, High Performance Fasteners, Rotary Latches and Snap Fasteners.

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Clamp power to production

Models MTU (above, left) and MTS (above, right) Multiple Plate Clutches are available in dry or oil types. Sizes 3" to 12", working capacities .47 to 44 hp per 100 rpm. Request Bulletin 134-B.

Design Twin Disc Models MTU, MTS Multiple Plate Clutches into your machines . . . *and you provide the capacity to effectively transmit higher loads required for maximum production.*

With comparatively *low* pressure on the control lever, Twin Disc Multiple Plate Clutches provide *high* clamping efficiency. Add their *short* travel, and you have minimum clutch length . . . *permitting high torque capacity to be designed into minimum space.* To maintain high torque capacity, the Models MTU, MTS feature materials with high friction coefficient, plus an ample number of friction surfaces.

Also important, Twin Disc Multiple Plate Clutches permit higher speeds of rotation, for their operating mechanism is designed to be *unaffected* by centrifugal action. Adjustment is single-point for time-saving simplicity. All sliding surfaces are specially hardened to eliminate possibility of scoring parts.

Whatever your requirement, Twin Disc can provide the right type, right size Multiple Plate Clutches for greater efficiency. The Models MTU (duplex) and MTS (single) are mechanically-actuated. New Twin Disc Models MOD (duplex) and MOS (single) Multiple Plate Clutches are oil-actuated, with the floating or pressure plate acting as the cylinder ram.

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Friction Clutches and Fluid Drives

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discussion concerning the physical principles involved in the toy boat and particularly what controls the frequency of "put-put," I made a search in the Engineering Index, and such treatises on prime movers as I could find, in an attempt to discover a description and possible analysis of the mechanism. Nowhere could I find any reference to this mechanism. So, I appeal to you, and to any *Product Engineering* reader who may have some knowledge of this "gadget," for some literature reference and/or analysis of it. Any help will be much appreciated.—WILLIAM E. MYDANS
Livingston, N. J.

ED—In so far as the basic principle of operation is concerned, we think it is relatively simple. Steam generated in the brass chamber is suddenly progressively condensed when the steam reaches the cold water. This sucks cold water through the tube and into the chamber. As soon as the cold water hits the top chamber it vaporizes into steam and is blasted out through the tubes. The water in the tube ahead of the column of steam creates the jet propulsion. As soon as the water is expelled from the tube and the steam hits cold water on the outside, the cycle is repeated.

It would require considerable mathematics to determine the rapidity of the action, i.e., the frequency of "put-put." Now let us see what further information readers can furnish.

Corrections

On page 289 of the December, 1954, *Product Engineering*, the address given for the Spaulding Fibre Co.'s main office was 585 Boylston St., Boston. The correct address, 310 Wheeler St., Tonawanda, N. Y., has now been supplied to us by this manufacturer.

The manufacturer, Valcor Engineering Corp., Kenilworth, N. J., of the new lightweight solenoid valve described on page 220 of the November, 1954, *Product Engineering* report that they mistakenly gave the weight of this product as 33 lb. The valve actually weighs 0.33 lb.

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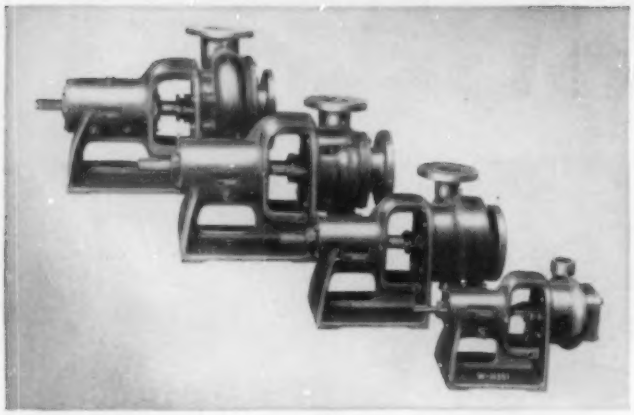
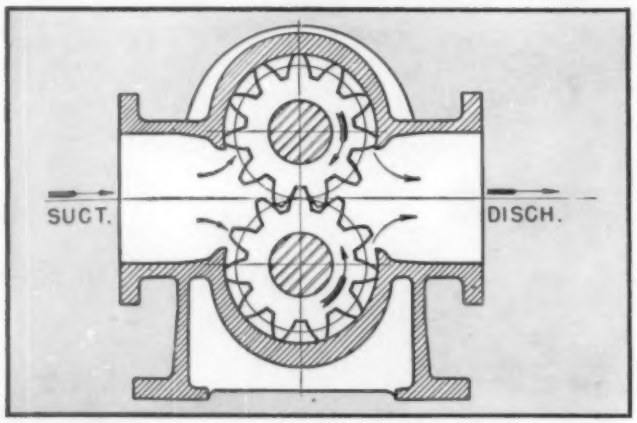
WHAT'S YOUR P.Q.*?

* Pump Quotient



Why are more and more end-suction pumps being specified? The answer's *simplification.* Industry is turning to end-suction pumps because they simplify piping (especially in process applications), need only one stuffing box, and make parts replacement easy. Get the full story on the Worthington end-suction pumps by writing to Section PC.4.8.

What is Worthite? Worthite is Worthington's "super-stainless", corrosion-resisting alloy steel containing more than 50% of the alloying elements: nickle, chromium, molybdenum, silicon, copper and manganese. The balance is mainly iron. Worthite was first introduced in 1936 and has gained wide acceptance as an excellent construction material for applications where corrosion is a problem. Worthington, of course, offers a complete line of Worthite pumps. Write for Bulletin W-350-B4.



Why are gear-type rotary pumps best for handling high-viscosity fluids? Lots of reasons. First, their large, unobstructed passages mean low entrance losses. Then, there aren't any valves or valve springs. Also, there's the flexibility in application offered by the wide speed range of gear-type rotaries. Write for Bulletin W-483-B2 for facts about the Worthington double-herringbone gear rotary pumps and vane pumps. PC.4.10

Write today for bulletins on end-suction pumps, Worthite and gear-type rotary pumps. Worthington Corporation, Merchandising Division, Section PC.4.10, Harrison, New Jersey.

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Channel Models

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The Model 158-5460 eight-channel system (upper left photo) consists of an eight channel recorder assembly and eight Driver Amplifier-Power Supply units. To this basic assembly the user adds any combination of Sanborn "150" plug-in preamplifiers to meet his requirements. Each channel provides a 4 cm deflection.

The six-channel system (156-5460) has the same basic assembly, except for *two less* galvanometers and *one less* Driver Amplifier-Power Supply unit in each cabinet. Each channel provides a 5 cm deflection.

Both systems offer: *nine* chart speeds (0.25 to 100 mm/sec.); *extended* frequency response; *improved* regulated power supplies; *individual* stylus temperature control for each channel; *improved* control of input signals by 1, 2, 5, 10, 20, etc. attenuator ratios; controls for timing, manual and remote coding.

Also 8 and 6 Channel Systems for recording analog computer outputs,

or other applications where 1 volt/cm sensitivity is usable. complete **eight-channel** system shown comprises four Model 150-2000 **Dual Channel** DC Amplifiers and an eight-channel Recorder Assembly. Each Dual-Channel Amplifier is complete with common power supply. (The six-channel version is identical, except for **two less** galvanometers and **one less** Dual-Channel Amplifier.) Also **four** channel models.

Write for catalog material on any Sanborn "150" Recording System

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in hidden tooling costs

THE difference between your costs and your competitors' may be hidden behind the production line. It's the cost of maintaining your tooling.

There's time lost for tool sharpening! Extra floor space for extra machines in the tool room! Skilled tool dressers! Chuck alignment and maintenance! Production lost for wheel dressing!

One answer to hidden tooling costs is Microhoning

Instead of bits to be sharpened and wheels to be dressed Microhoning uses self-aligning, self-dressing tools. Throughout their life Microhone abrasives make clean, uniform cuts.

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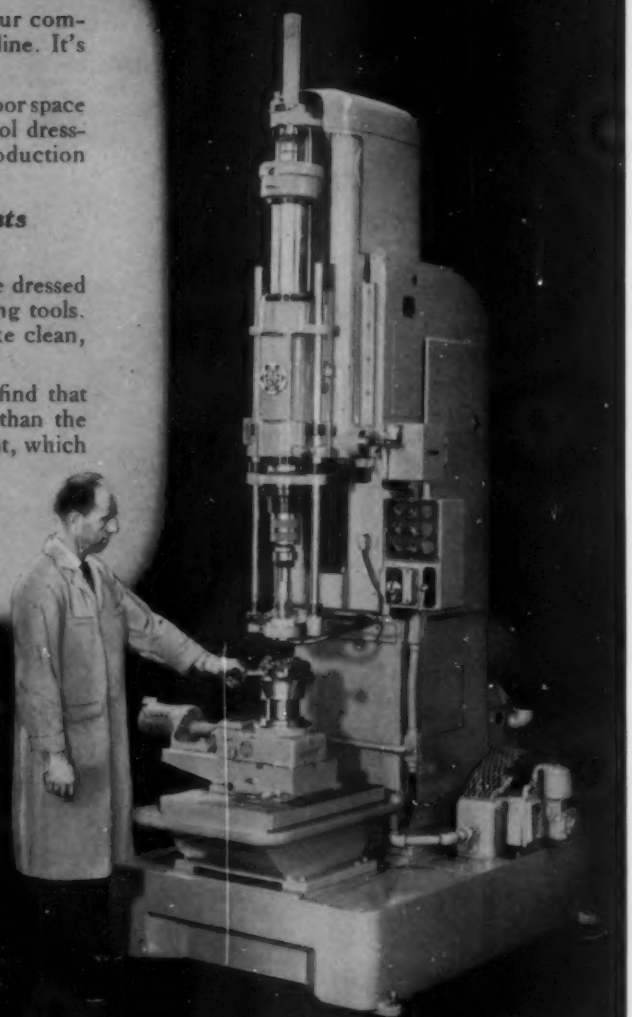
SOLUTION:

MICROHONING—Tool self sharpening—annealing not necessary—clean, consistent surface finish generated.



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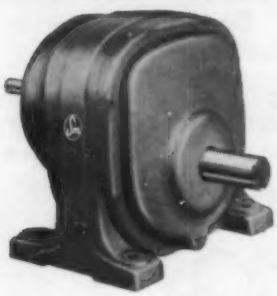

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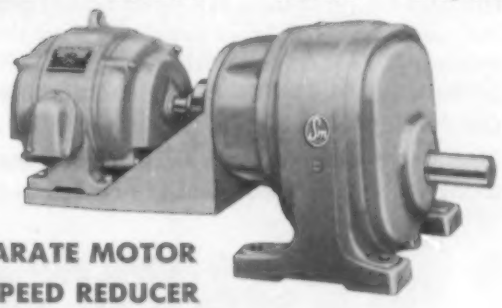
Available with feet or footless, face or flange mounted.



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For applications where separate motor reducer combinations are desirable.

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• Moving parts are reduced to a minimum by the compact design of these HE series helical gear type hydraulic pumps. All four capacities have the same mounting. Side or end porting, or a combination, is available. When used as fluid motors this series can develop up to 20 H.P.

Manufactured with anti-friction bearings, extremely dense cast iron bodies and selected alloy steel shafts, WEBSTER HE Series pumps and fluid motors are engineered and precision-built for economical service and long life. Designed for use with non-corrosive liquids with lubricating qualities.

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No doubt you too can save time—save materials—and increase your profits by using

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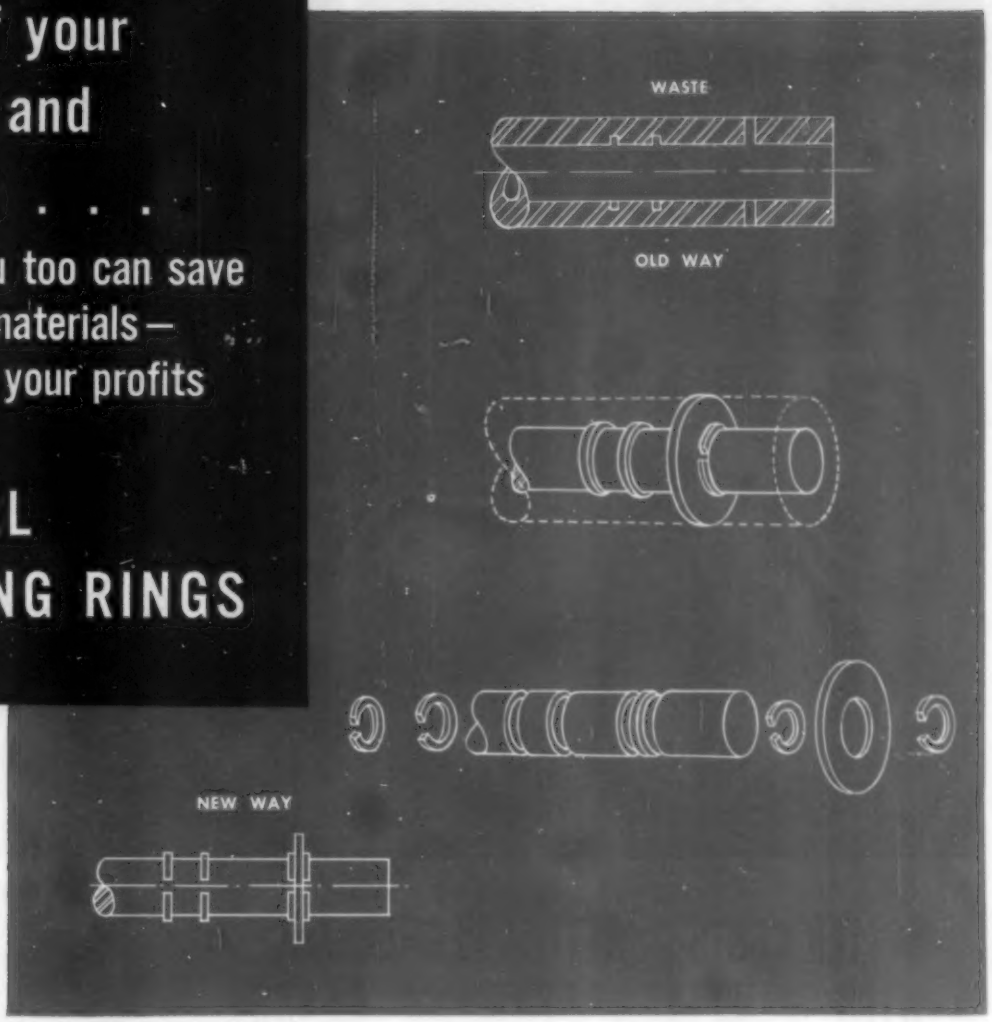

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THE NATIONAL LOCK WASHER CO.

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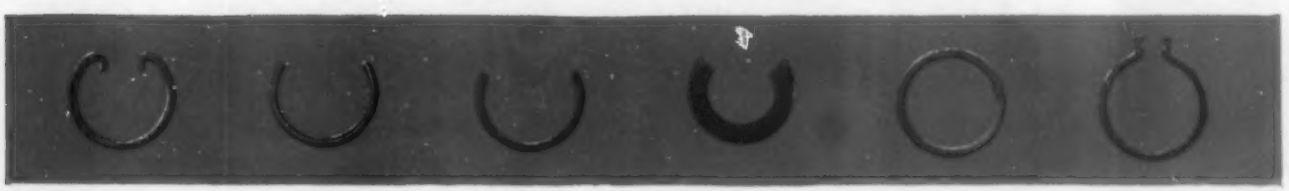


BETTER COSTS . . BETTER PERFORMANCE WITH WINZELER *STAMPED* GEARS

More and more cost conscious buyers are turning to the *Stamped* Gears we make. They get better costs . . better performance . . *better Gears!*

You see, we specialize in quantity runs of *Stamped* Gears . . producing them by the hundreds or thousands to a degree of accuracy and uniformity you never dreamed possible! Now for many purposes, single Stampings are laminated and indexed to make wider faces. Intricate assemblies of our precision *Stamped* Gears are highly successful for a lot of unusual applications.

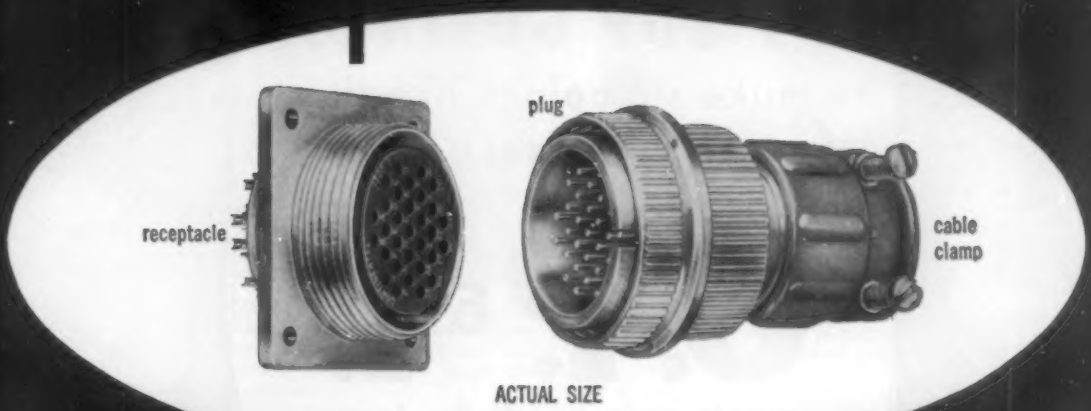
You, too, can probably switch to WINZELER *Stamped* Gears with big savings for yourself and greater satisfaction for your customers. Let our well trained staff give you ideas, suggestions and cost estimates. Write TODAY!

FREE! STAMPED GEAR GUIDE

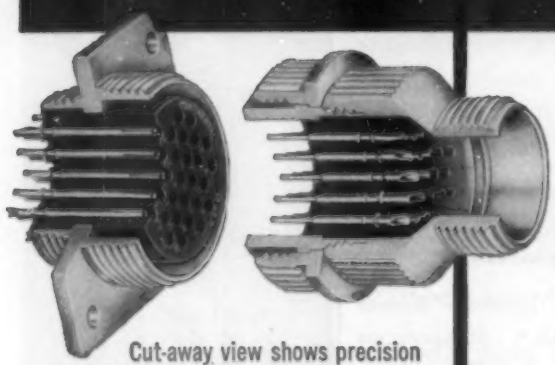
SEND TODAY *for useful 4-page folder . . a valuable guide to all that is best in the mass production and use of low-cost Stamped Gears, Tools and Assemblies. Many various types are described. Also contains technical data, tables, ideas, suggestions. Use company stationery, please!*

WINZELER MANUFACTURING & TOOL CO.
1712 WEST ARCADE PLACE • CHICAGO 12, ILLINOIS

new...precision Continental Connectors



miniature AN-type



Cut-away view shows precision construction of Continental Series 1300

CONTACTS FOR #20 AWG WIRE

NO. OF CONTACTS	SHELL SIZE
4 and 5	7/16 -24
15, 19, 27 and 31	1 3/16 -18

If you have been looking for a dependable, miniaturized version of the popular A N-type connector, then consider this new Continental Connector Series 1300.

Two small shell sizes accommodate several contact arrangements. The shells are precision machined aluminum, threaded for use with conventional cable clamps. Brass pin contacts and spring temper phosphor bronze female contacts are gold plated for easier soldering — pre-tinning of solder cups is unnecessary. Each contact is individually floating, to assure self-alignment and reduced engagement forces.

One-piece molded inserts prevent moisture traps and possible electrical breakdown. They can be interchanged between the plug and receptacle shells for greater versatility. Our standard molding compound is Mineral filled Melamine (MIL-P-14D, Type MME). However, other compounds are available on order.

Write to our sales engineering department for technical data on the Series 1300, PLUS other special designs and circuit applications requiring the use of sub-miniature, printed circuit, hermetic seal, pressurized, high voltage or power connectors.

JUST OFF THE PRESS!

98-page technical catalog for engineers, purchasing executives and engineering libraries. Gives detailed specifications on Continental precision connectors. Request a free copy on your company letterhead, indicating your name and title.

Electronic Sales Division **DeJUR**

WASHING MACHINE TUB

Seamless Drawn
Vitreous Enameled
Height.....34¼"
Diameter.....22"

BASE FOR SWIVEL CHAIR

Seamless Drawn Carbon Steel
Length 25" Height 4"

MIXING BOWL

Seamless Drawn Carbon Steel
Welded Brackets
Diameter.....14"
Height.....10½"

it's our business
to make stampings like these
for your business

G. P. & F.

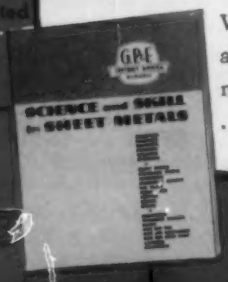
meets your needs for large and medium size seamless stampings PLUS complete finishing and assembly facilities

Shown here are just a few of the hundreds of different kinds of seamless drawn stampings we have manufactured for America's foremost companies. We made them **economically,** we made them **right,** we made them **on time.**

Our services do not end with stamping. We have complete facilities for finishing and assemblying, galvanizing, spray finishing, vitreous enameling, welding. If desired, we even package your products and ship to your customers!

Over 1000 skilled people . . . 293 deep draw and stamping presses . . . 97 welding machines . . . backed by 75 years' experience . . . are at your beck and call. Get full details . . . now!

Write for your copy of booklet—"Science and Skill in Sheet Metals." It illustrates many jobs produced for G. P. & F. customers . . . gives complete data on our facilities.



COMMERCIAL HAND DRYER

Seamless Drawn
Vitreous Enameled
Length.....12"
Width.....10⅛"
Height.....6¼"

TUB AND COVER FOR PORTABLE DISHWASHER

Seamless Drawn Aluminum
Baked Enamel Finish
Height of Tub....11"
Length and Width 17"

AMMUNITION BOX
(U. S. Ordnance)

Carbon Steel—Spray Painted
Length.....10"
Height.....7"
Width.....3⅛"

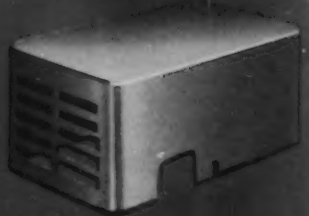
COVER, FUNNEL AND TANK FOR SOAP DISPENSER UNIT

Seamless Drawn Brass
Height of Tank....7"
Dia. of Tank.....4¾"

DEEP FAT FRYER POT

Seamless Drawn Stainless Steel
Height.....19"
Length and Width..17⅛"

COVER FOR OIL BURNER UNIT



Seamless Drawn Carbon Steel
Height 5⅛" Length 12½"
Width.....7½"

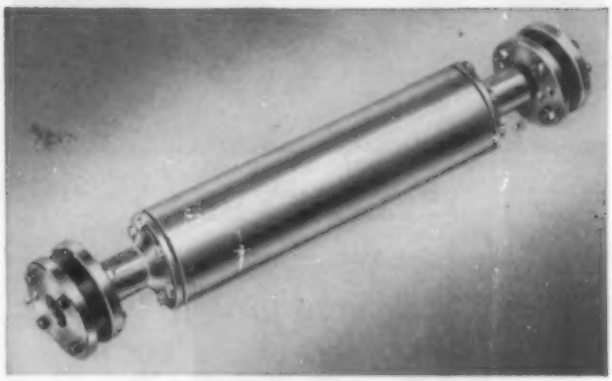
GP&F DIAMOND ANNIVERSARY 1880 1955

GEUDER, PAESCHKE & FREY CO., 1505 W. ST. PAUL AVE., MILWAUKEE 1, WISCONSIN

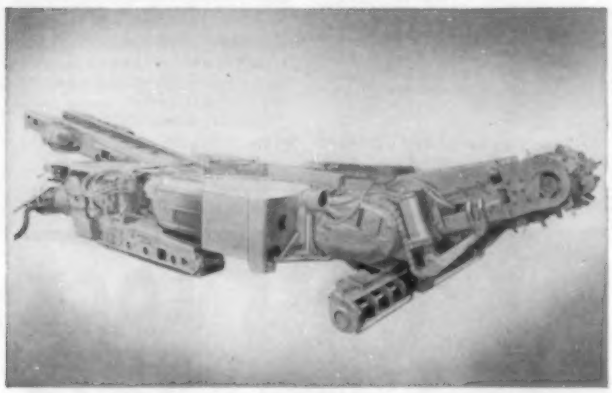
How Rzeppa Joints Solve Critical Drive Problems . . .

Changing or Fixed Angles – High or Low Speeds

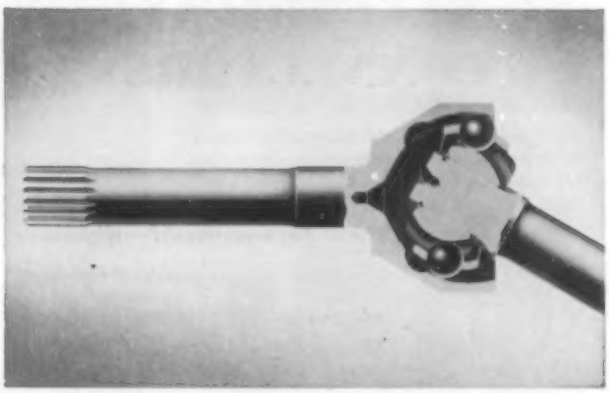
LOW ANGLE — HIGH SPEED Up to 3° at 8,000 rpm. Aircraft uses the Rzeppa disc type for auxiliary power take-off shaft drives because constant torques and speeds are transmitted. This type is especially adaptable to those applications where vibration is critical.



Rzeppa disc type joints are of rugged design. Are available in either spline-driven or bolt-driven types. A flexible neoprene seal permits working angles up to 18°.



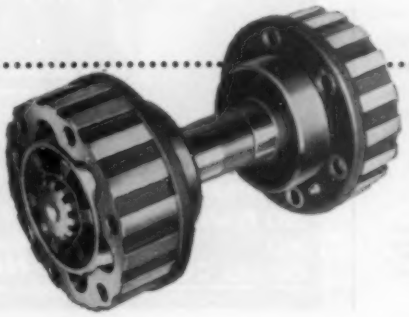
HIGH ANGLE — LOW SPEED Up to 35° at 400 rpm. Continuous miner really uses the versatility of Rzeppa bell type joints. Its working angle is constantly fluctuating. Bell joints are especially suited for power steering drives or articulated driving axles with independent wheel suspension.



Rzeppa bell type joints are constructed with a spline shank. Are easily sealed in axle housings or other machine components. Will handle working angles up to 35° depending on seal types and housings required.

Somewhere between the two applications shown lies the answer to more effective joint performance for you. Because of their versatility, Rzeppa Constant Velocity Universal Joints are transmitting a uniform flow of power in these and hundreds of other applications — including machine tools.

By transmitting true, constant rotating motion, Rzeppa Joints wear longer, have higher capacity, are more compact, and operate with less friction. That's why Rzeppa Joints carry heavier loads for their size than any other type. Disc type or bell type, you get ruggedness and versatility. Don't you, too, have an application that can use these performance advantages? Our catalog may help answer that for you. Send for it today.



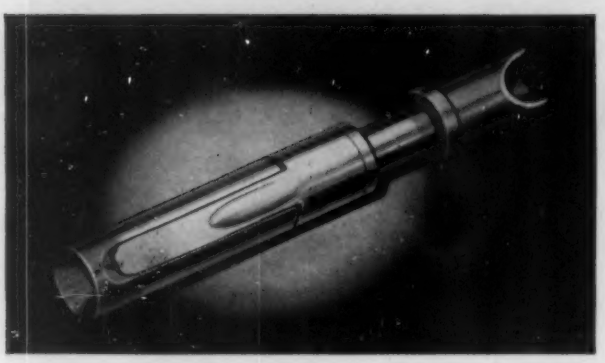
TYPICAL DRIVE LINE APPLICATION – Jointed shaft for independently sprung rear axle and propeller shafts for industrial applications.

RZEPPA Constant Velocity UNIVERSAL JOINTS

Joint Division

THE GEAR GRINDING MACHINE CO.

3939 Christopher, Detroit 11, Michigan



"CLIP-TYPE"
closed entry socket contact
now standard in

BENDIX SCINFLEX ELECTRICAL CONNECTORS

Cannot be overstressed—eliminates intermittent circuit problems resulting from socket contact malfunction.

The heart of any electrical connector is the socket contact. This is why the Bendix-Scinflex* socket contacts have always been machined from bar stock. Stampings, with their required thin sections, can be easily overstressed.

Even with the machined sockets, industry has been plagued with overstressed spring leaves due principally to the misuse of test probes and lax tolerances on pin contacts. Bendix engineers have now provided the only socket contact on the market today which completely eliminates all these problems.

The "Clip-Type" socket will not accept any oversize probe or pin nor can one be forced into it. Also, no amount of wrenching or twisting of an acceptable pin or probe can possibly distort the spring clip. This new socket is now standard in all Scinflex connectors including those using solderless, high-temperature and thermocouple contacts.

Our sales department will be glad to furnish complete information on request.

*TRADE-MARK

SCINTILLA DIVISION of Bendix
SIDNEY, NEW YORK
AVIATION CORPORATION

Export Sales: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.
FACTORY BRANCH OFFICES: 117 E. Providencia Ave., Burbank, Calif. • Stephenson Bldg., 6560 Cass Ave., Detroit 2, Michigan • 512 West Ave., Jenkintown, Pa. • Brouwer Bldg., 176 W. Wisconsin Avenue, Milwaukee, Wisconsin • 8401 Cedar Springs Rd., Dallas 19, Texas • American Bldg., 4 S. Main Street, Dayton 2, Ohio • 1701 "K" Street, N. W., Washington 6, D. C. • Boeing Field, Seattle 8, Washington.

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● Dipped, form-dipped, molded, extruded rubber parts, fabricated sponge parts . . . vast, complete facilities . . . new, advanced production methods . . . these ARco services assure you rubber parts that will meet your "tightest" production schedules.

Give your product the advantages of sound abatement, electrical and thermal insulation, corrosion and abrasion resistance with rubber.

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M·F LOCK NUTS

"FEW OLDER IN EXPERIENCE— NONE YOUNGER IN FACILITIES AND DESIGN."

THIS IS THE M-F *Uni-Torque*

- A seasoned organization—
- Using the most modern facilities from laboratory to tool room to production machinery . . .
- Has developed techniques and methods which create in a simple low-cost product—
- *Reliability of torque never before thought possible.*
- Try the M-F Uni-Torque for yourself.

NO SLOTS
NO FIBRE
NO PLASTIC
NO *EXCESS COST!*

Mac Lean-Fogg Lock Nut Company
5535 North Wolcott Avenue, Chicago 40, Illinois

Compare actual O-ring samples

Prove by comparison tests how Parker O-rings seal better and last longer

For trouble-free leakproof sealing, you can depend on Parker O-rings. They are precision molded of superior compounds that have been developed as the result of thousands of tests.

Elongation, tensile strength, compression set ratings, resistance to oils, fuels, chemicals, and high and low temperatures, are determined with care. Then, laboratory and service tests make sure that all rated characteristics are held.

From Parker you can get exactly the *right* O-ring for your *specific* application. We invite you to compare Parker O-rings with any other make. Our engineering service will also help you with designing problems.

Send for complete engineering data today. Mail the coupon for your *free* data book or ask your Parker O-ring distributor for a copy.

RUBBER PRODUCTS DIVISION
The Parker Appliance Company
17325 Euclid Ave., Cleveland 12, Ohio
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Parker
Hydraulic and fluid system components

Laboratory and service tests check compound resistance to oils, fuels and chemicals at high and low temperatures ... assuring the long life of Parker O-rings.

Precision molding by exclusive, automatically controlled methods assures close-tolerance fits. Parker has molds for every *standard* O-ring size. Send for data.

What other Parker products for aircraft applications interest you? We build jet-engine accessories (shown above) for engine *fuel, hot-air* and *hydraulic* systems.

RUBBER PRODUCTS DIV.
Section 511-L
The Parker Appliance Co.
17325 Euclid Avenue
Cleveland 12, Ohio

Please send me the following information:

- ☐ O-ring catalog No. 5100
- ☐ Also, please send me your new 24-page book about Parker engine accessories Bulletin No. 133081.

NAME_____ TITLE_____
COMPANY_____
ADDRESS_____
CITY_____ STATE_____

Announcing a versatile new line of reducers

CONE-DRIVE SHAFT MOUNTED SPEED REDUCERS

Now, designers can take advantage of the unique double-enveloping worm gear design of Cone-Drive gears in shaft mounted speed reducers. The right angle between input and output shafts offers many application and space-saving advantages over conventional gearing. The reducers are mounted directly on the driven shaft and require only a simple bracket or torque arm to prevent rotation of the reducer.

The new reducers can be readily motorized, if desired. A bell housing is available to accommodate standard NEMA C-type flanged motors. Expensive couplings are not required since a tang-type drive sleeve and suitably machined worm are provided with the bell housing to match the motor shaft being used.

Standard reduction ratios range from 5:1 to 60:1. When the motor is connected to the input shaft by means of vee-belts or pulleys, additional speed reduction can be easily obtained. Bore sizes are available to accommodate shafts from 1" to 2½" in steps of 1/16". All sizes are available from stock.

Complete engineering details are available in Bulletin CD-323. It's free for the asking.

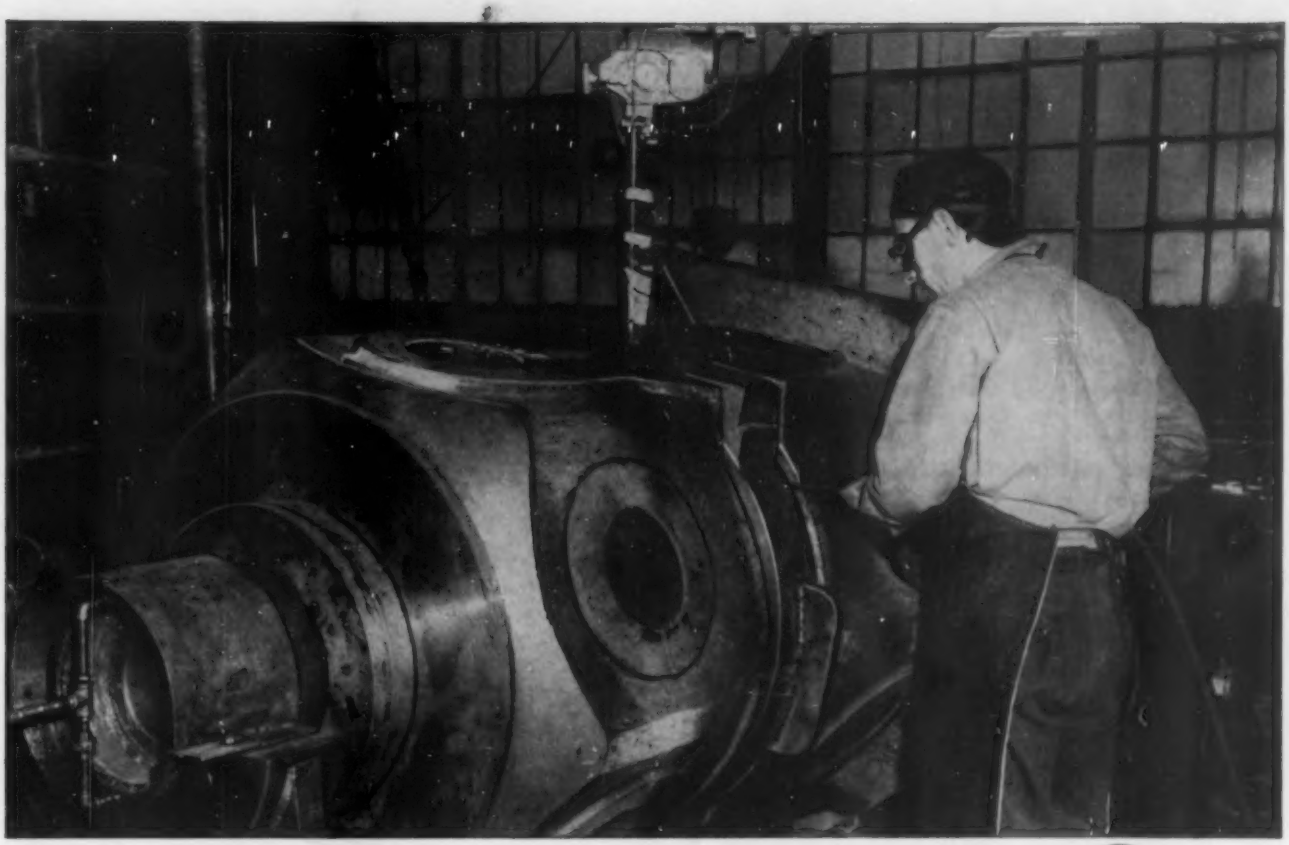
MORE HP PER POUND ★ MORE HP PER CUBIC INCH ★ MORE HP PER DOLLAR

CONE-DRIVE GEARS

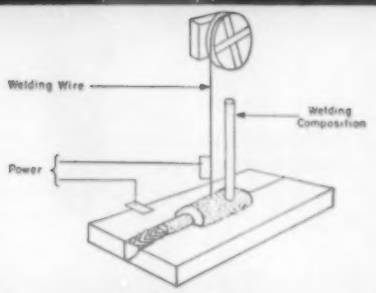
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS

Division, Michigan Tool Company

7171 E. McNichols Road • Detroit 12, Michigan



UNIONMELT Welding Solves "Impossible" Casting Job . . .



UNIONMELT welding solved the problem when a manufacturer was unable to make one-piece castings of compressor cylinders used in gas line pumping stations—other welding methods proved too slow and costly . . . UNIONMELT welding cuts 40 hours in production time, and produces high-quality welds that easily withstand pressure of 750 lb. per sq. inch.

The 42-in. diameter cylinder is cast in two halves, and has an internal piston bore with surrounding suction and exhaust chambers . . . The 2½-in. thick piston walls and 3-in. thick outer walls of each half are aligned and UNIONMELT welded.

Like many other products throughout industry, these cylinders are being fabricated faster and more economically than ever before, because UNIONMELT welding offers:

- Higher welding currents than other welding processes . . . Up to 4,000 amperes . . . Joins metal of any thickness.
- Greater economy—½ to ⅔ less welding wire . . . Also uses larger-diameter, less-expensive wire.
- Use of any power supply—a.c., d.c., or constant potential . . . With c.p., no control is necessary to maintain constant arc voltage—welding is fast and more easily controlled.

Start saving now—call your local LINDE representative for more information and ask for Form 7942, "Modern Methods of Joining Metals."

Linde Air Products Company
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.

Offices in Other Principal Cities
In Canada: DOMINION OXYGEN COMPANY
Division of Union Carbide Canada Limited, Toronto

The terms "Linde" and "Unionmelt" are registered trade-marks of Union Carbide and Carbon Corporation.

Linde
Trade-Mark

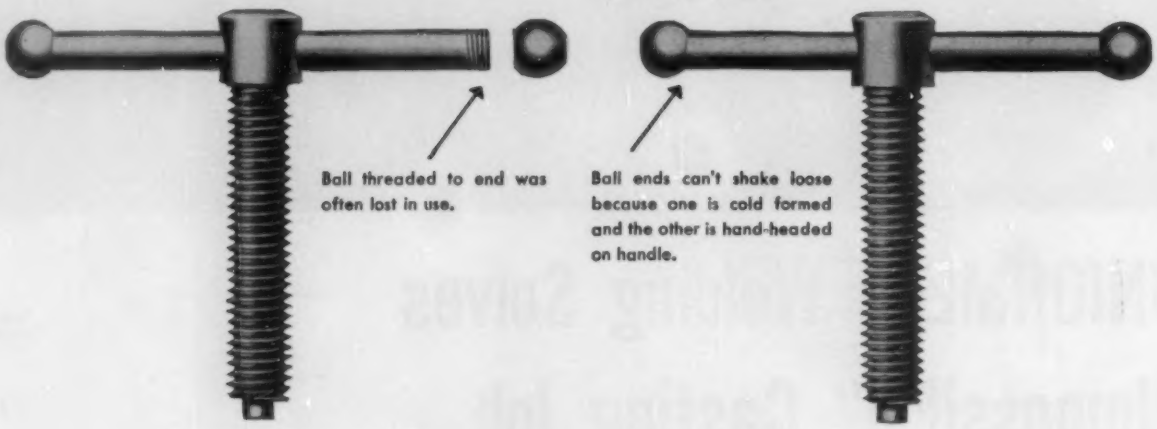
Assembly operation eliminated

The old way:

This vise handle was originally cut from bar stock by screw machine. One end of the handle was threaded while the other was machined to a ball head. To complete the assembly a separate internally threaded ball head had to be screwed onto the threaded end by hand.

The National way:

Our "Special Products Service" showed how this vise handle could be produced faster and at lower cost by cold heading. The handle and one head were cold formed to required dimensions. Then, the handle was inserted through the drilled hole in the head of the jaw adjusting screw and the other end was hand headed. Result . . . substantial savings in material and production costs.

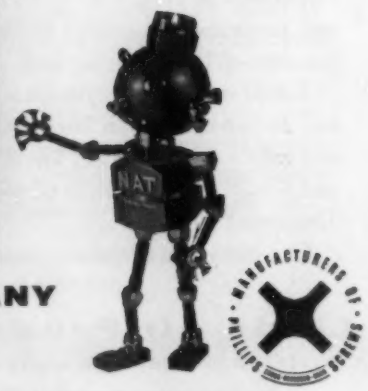


Ball threaded to end was often lost in use.

Ball ends can't shake loose because one is cold formed and the other is hand-headed on handle.

Bring your "Special" problems to National

National has the experience and wide range of cold heading equipment needed to solve many "special" problems. Our "Special Products Service" representative will be glad to study your requirements. Write for free copy of National's "Special" fastener booklet.



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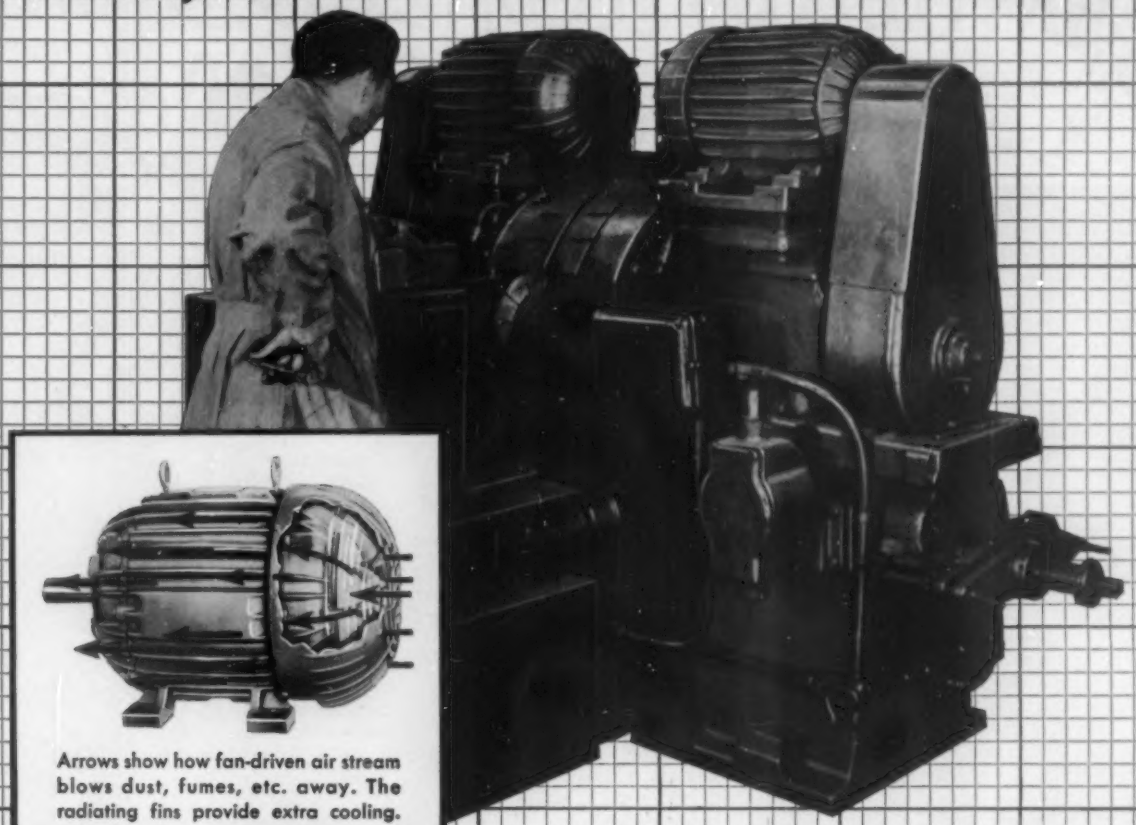
THE NATIONAL SCREW & MFG. COMPANY
Cleveland 4, Ohio
Pacific Coast: National Screw & Mfg. Co. of Cal.
3423 South Garfield Ave., Los Angeles 22, Cal.

National PRODUCTS

Fasteners Hodell Chains Chester Hoists

IF DUST, DIRT OR FUMES ARE IN THE PICTURE...



Arrows show how fan-driven air stream blows dust, fumes, etc. away. The radiating fins provide extra cooling.

Abrasive dust from the precision grinder won't bother these Sealedpower motors.

Specify ELLIOTT C-W Sealedpower Motors

Elliott C-W Sealedpower motors are also built in approved explosion-proof design for hazardous locations.

These totally-enclosed, fan-cooled motors insure your machines against failure, production time losses and costly maintenance in dirty, exposed areas. A steady stream of cool fan-driven air keeps dust from settling on the frame and drives off the heat radiated from the finned motor casing. For extra protection, Sealedpower motors are effectively sealed against liquid penetration. Wide range of modifications such as with gear or brake, explosion-proof enclosures. Sizes 1 to 100 hp, NEMA frames. Full details in Sealedpower Motor Bulletin. Write Elliott Company, Crocker-Wheeler Division, Jeannette, Pa. for your copy.

ELLIOTT Company

W5-1

TURBINE-GENERATORS TURBINES MOTORS GENERATORS DEAERATING HEATERS EJECTORS CONDENSERS COMPRESSORS TURBOCHARGERS TUBE CLEANERS STRAINERS

THE BOSTON MAN
in your area is ready
to serve you . . . today!

Boston Silver King Rotocord Conveyor Belt. 1680 feet long, 26,350 lbs.

The mammoth belt pictured above stood too high on its freight car to pass through many of the railroad tunnels and underpasses en route to its West Virginia destination. Boston Men rolled up their sleeves . . . teamed up with railroad freight traffic experts . . . pored over maps and timetables. As a result, the giant was rerouted many miles, but it wasn't late for its installation.

Good service is a Boston product. Fast delivery can mean savings in money and man-hours to a customer. For that reason, Boston offers direct, immediate service from warehouses located strategically throughout the country.

Tailoring industrial rubber products to specific uses . . . the above-pictured belt, for example . . . is a specialty of Boston Men. Boston experts visit customers' plants and mines . . . talk to the men who use industrial rubber . . . study plant processes and working conditions. Back in Boston's Research and Development labs, they find the answers.

Do you need an answer to an industrial rubber problem?
See our distributor in your area. He is your "Boston Man."

BOSTON

BOSTON WOVEN HOSE & RUBBER CO., Box 1071, Boston 3, Mass.

Industrial Hose • Fire Hose • Belting • V-Belts • Packing • Tubing • Garden Hose • Tape • Matting and Stair Treads

One Satisfied Customer tells another...

When women get together, appliances are bound to get into the conversation before long. Then one of a manufacturer's best salesmen—the satisfied customer—can really do a job for him. When the talk is about *Packard*-powered appliances, the job is done with extra enthusiasm—from sheer satisfaction.

For over 38 years Packard Electric motors have been giving dependable, low-cost service to users. The appliance maker who standardizes on Packard fractional horsepower motors benefits from the satisfaction they give, from enhanced reputation and from increased sales.

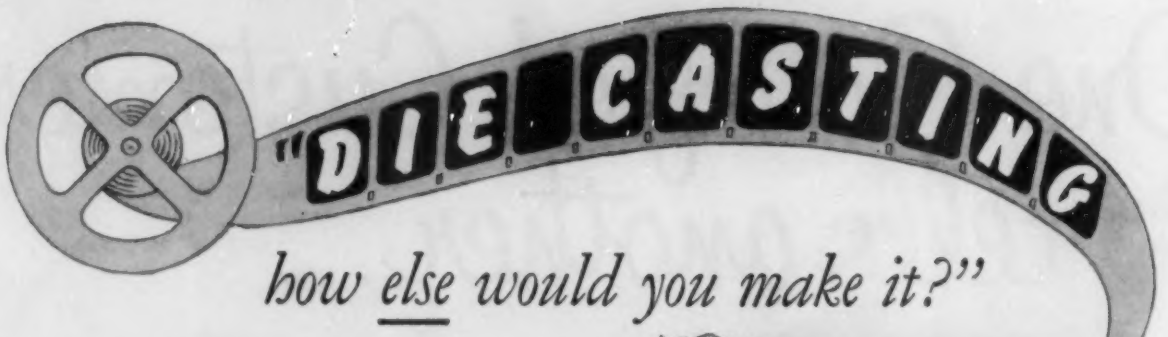
BRANCH OFFICES:
DETROIT 2, MICHIGAN, OAKLAND 12, CALIFORNIA,
OAK PARK, ILLINOIS

GM GENERAL MOTORS

Packard

REG. U.S. PAT. OFF. TRADE MARK

Packard Electric Division,
General Motors,
Warren, Ohio



Now SEE and HEAR

what Die Casting can do for you!

Every design and production engineer should see the new 16mm color and sound motion picture, "DIE CASTING – How else would you make it?". This brand-new picture not only establishes the relationship of die casting to other high-speed production methods, but it fairly presents the place of zinc among the die casting metals. Prints of the film, which runs 35 minutes, are available now for use by industrial organizations, technical societies, engineering colleges and government agencies. They can be borrowed free of charge from the producer of the picture, the American Zinc Institute, Inc., 60 East 42 St., New York 17, N.Y. *When writing, try to give several alternate dates for the showing.*

Once bookings for the film are accepted by the American Zinc Institute, arrangements can frequently be made through the cooperation of the American Die Casting Institute, a national association of jobbing die casters, to provide technical commentators and exhibits for film showings. A 28-page booklet entitled, "Die Casting – Molten Metal to Finished Part... Direct," which contains supplementary technical information, has also been prepared by the American Zinc Institute and will be made available for distribution among the audience following the film presentation.

The picture should be of interest not only to potential users of die castings, but also to manufacturers who are now using die castings in the assembly of their products. They will find the film helpful towards re-evaluating both the die casting process and the metal zinc in the light of the latest developments in this rapidly growing industry.

↑ *top:* Automotive defroster duct zinc die castings being removed from the dies in a die casting machine. These die castings are made at the rate of 750 sets an hour.
bottom: A 60-in. long, 22-lb. zinc die cast automotive radiator grille being removed from the die casting machine die prior to buffing and plating operations.

(The above photos are part of case history sequences taken from the film.)

READ "Bunker Hill Zinc and Die Casting"... the story of DIE CASTING as a high-speed, low-cost production tool... ZINC and its advantages as a base metal for die castings... BUNKER HILL'S contribution to the phenomenal growth of the die casting industry. This new 8½ x 11", 24-page publication is yours for the asking. Write for copy on your company letterhead please.

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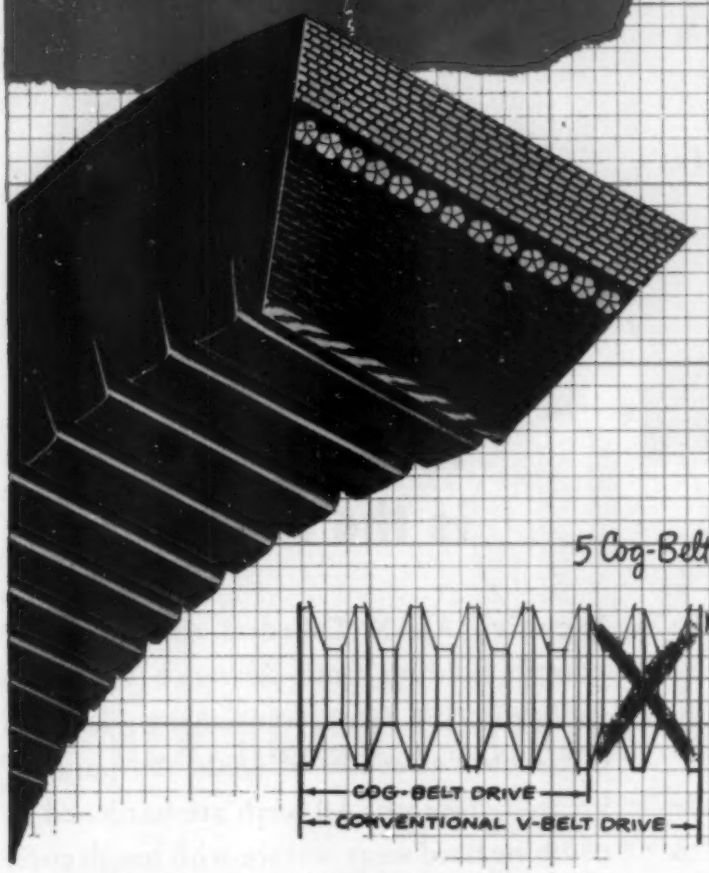
BUNKER HILL 99.99+% ZINC

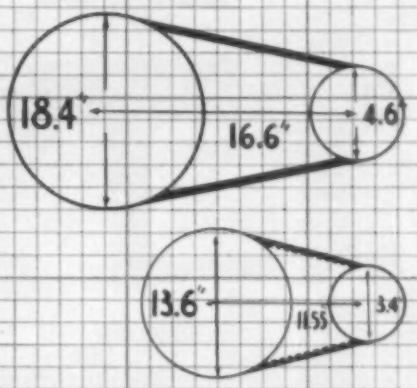
SALES OFFICE FOR PACIFIC COAST **NORTHWEST LEAD COMPANY** SEATTLE, WASHINGTON

Save Space by 47.2%

in your V-Belt drive design with Dayton Cog-Belts*



Cog Belts save space and weight



"B" CROSS SECTION 4 TO 1 SPEED RATIO
COG-BELT DESIGN EFFECTS A 30.6% SAVING IN CENTER DISTANCE – A 26% SAVING IN SHEAVE DIAMETERS – A 47.2% SAVING IN DRIVE AREA – A 28% SAVING IN WEIGHT

5 Cog-Belts do the work of 7 ordinary V-Belts

40% BONUS POWER PERMITS DESIGN FOR NARROWER SHEAVES, FEWER GROOVES, SAVES WEIGHT BY AS MUCH AS 28%

If your problem is to design a V-Belt drive to deliver the *full* power of your product in a limited operating space, yet still get consistent efficiency and long, economical service, you can do it with Dayton Cog-Belts.

You can use smaller sheaves with fewer grooves and shorter and fewer belts. For example, 5 Dayton Cog-Belts do the work of 7 ordinary V-Belts. Besides saving space, you reduce weight and costs.

They offer greater grip, strength, flexibility and heat and static dissipation for power drives characterized by high speeds. They're the perfect answer where short centers, small sheave diameters, continuous operation and excessive external heat, dirt, oil or grease are factors.

For prompt attention, write to: Dayton Rubber Company, Industrial Division, Dept. 872, Dayton 1, Ohio.

Check These exclusive Design Advantages:

1—The Tension Section flexes easily, giving longer life.

2—The Load Carrying Section has maximum stretch-proof strength.

3—The Compression Section has unequalled cross-wise rigidity.

4—Preformed, integral Cogs flex uniformly for full grip.

5—Smooth, die-cut sides assure positive grip, *full* power.

GOLDEN JUBILEE

Dayton Rubber 50 YEARS OF PROGRESS

*T.M.

World's Largest Manufacturer of V-Belts

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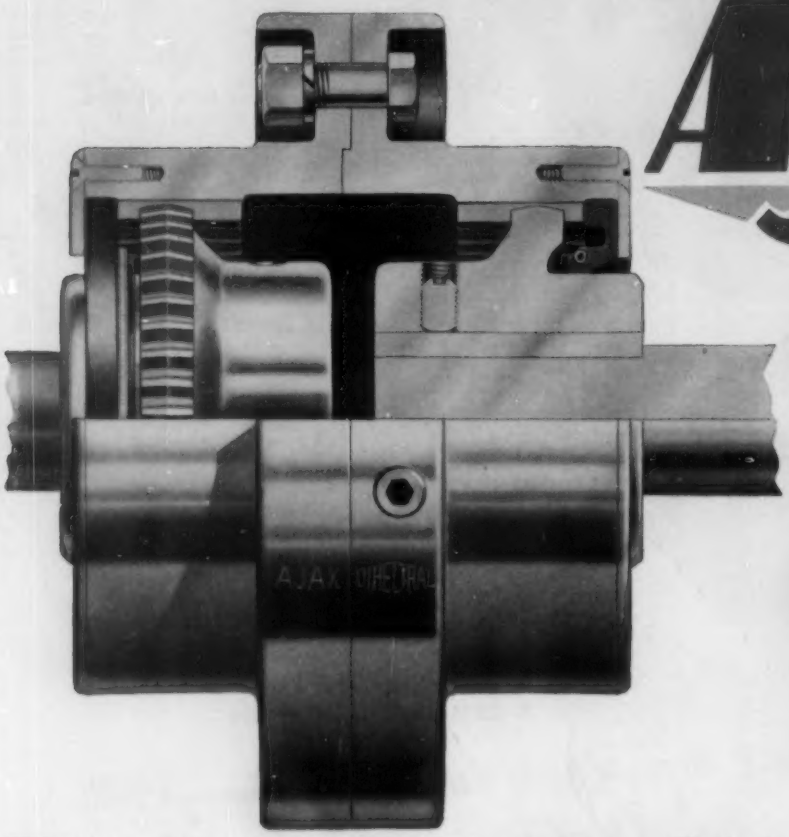
YOU can afford AJAX DIHEDRAL COUPLINGS because the best coupling is the cheapest



Whether your executive position concerns design, manufacturing, selling, maintenance or service,—the performance of your equipment depends on the coupling!

AJAX Dihedral Couplings are radically improved gear-type couplings designed to handle offset, angular and end float shaft misalignment far beyond capacities of conventional flexible couplings.

Simplify your machine design, manufacturing, installation and maintenance. AJAX Dihedral Couplings make it possible to design misalignment into heavy duty equipment as well as out.

Exclusive AJAX Dihedral tooth design* permits holding tooth clearance (backlash) to lubrication film requirements. Load is distributed at center of teeth, the point of greatest strength. All teeth are hardened to combine hard wear surface with tough core. Seals keep lubrication IN.

Phone the AJAX representative or write the factory for case histories,—you will spark-plug some worth-while thinking.

Also manufacturers of a complete line of AJAX Rubber-Bronze Bushed Couplings and Vibrating Conveyors.

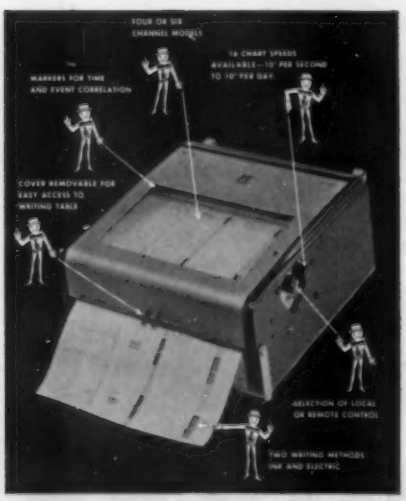
Representatives in Principal Cities
Consult your Telephone Directory

AJAX FLEXIBLE COUPLING CO. INC.
WESTFIELD, N. Y.

*Patents Pending

NEW BRUSH PORTABLE INSTRUMENTS

to simplify your data recording


FOUR OR SIX CHANNEL MODELS
MARKERS FOR TIME AND EVENT CORRELATION
16 CHART SPEEDS AVAILABLE—10" PER SECOND TO 10" PER DAY
COVER REMOVABLE FOR EASY ACCESS TO WRITING TABLE
SELECTION OF LOCAL OR REMOTE CONTROL
TWO WRITING METHODS INK AND ELECTRIC

Six-channel oscillograph (above) weighs 48 pounds. Four-channel model weighs only 36 pounds. Both units are equipped with electrically controlled chart drive transmission.

BRUSH Portable Recording Systems, combining amplifiers and direct-writing oscillographs, provide *complete systems* for recording several channels of data simultaneously. These systems have been completely redesigned to simplify your field testing.

Units are light in weight, durable, easy to set up. With one recording system, you can record a great variety of signals clearly and distinctly . . . chart speed can be as slow as 10 inches per day, as fast as 10 inches per second. Both ink and electric writing methods available. Instantaneous switching and provision for remote control operation add to their utility.

For complete information on the application of Brush Recording Systems to your measurement problems, contact your Brush engineering representative or write Brush Electronics Company, Department L-4, 3405 Perkins Avenue, Cleveland 14, Ohio.

Amplifier in Portable Carrying Case. This Universal* Amplifier can be used with either inductive or resistive transducers for recording physical variables.
*Trade-Mark

BRUSH ELECTRONICS COMPANY

INDUSTRIAL AND RESEARCH INSTRUMENTS
PIEZOELECTRIC MATERIALS • ACOUSTIC DEVICES
MAGNETIC RECORDING EQUIPMENT AND COMPONENTS

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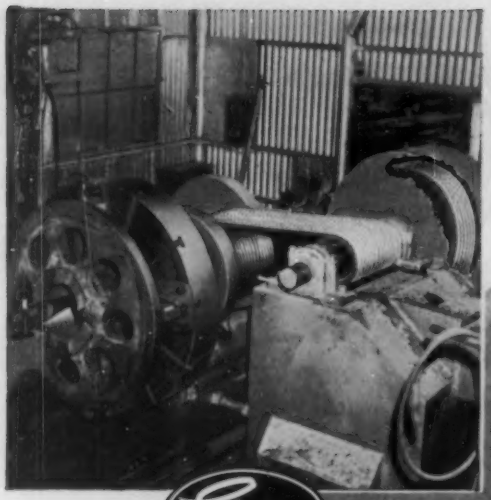
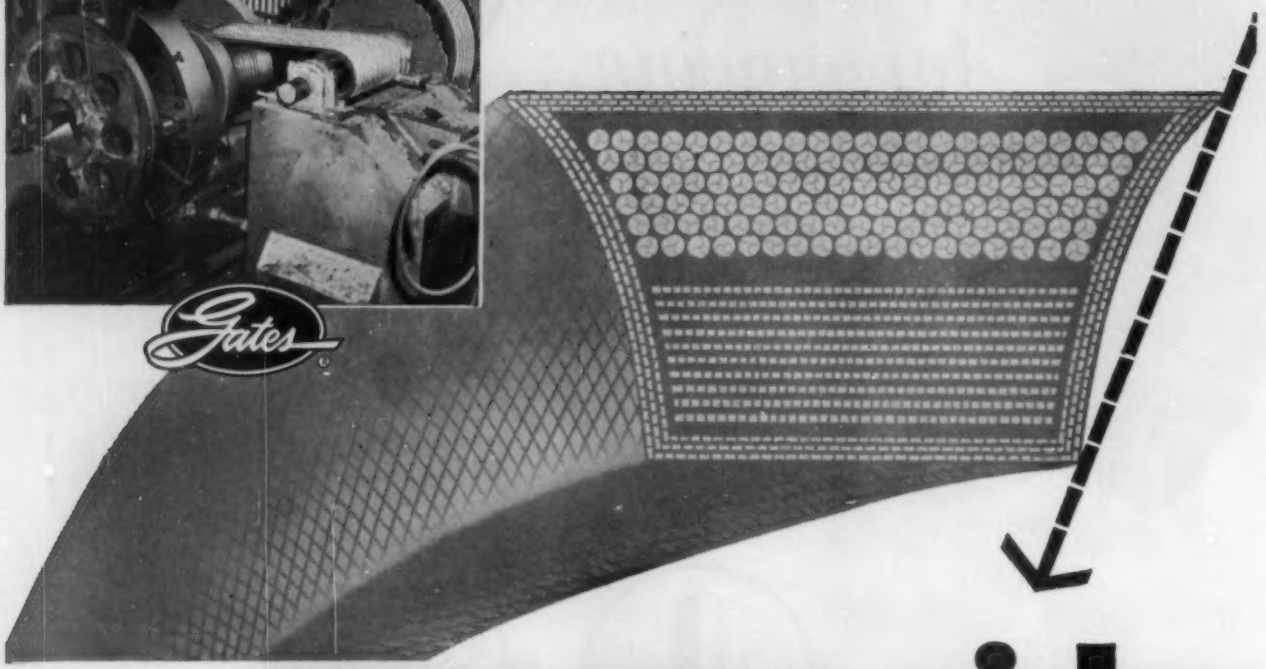
Division of Clevite Corporation



The smooth, positive flow of power transmitted through Gates Vulco Ropes enables this large engine lathe to handle quickly and efficiently many tough oil field repair jobs.



How concave sides cut V-belt costs!

Plants all over the world have made this discovery: Gates Vulco Ropes—the V-belts with *concave sides*—wear longer; cost less per year of service.

Here is the interesting reason why:

When the Gates Vulco Rope is bent around the sheave, the *precisely engineered* concave sides (Fig. 1) fill out and become straight (Fig. 1-A). Thus the belt makes full, uniform contact with the sides of the pulley. You get sure pulling power and *even distribution of wear.*

Longer wear saves not only on replacement costs; it also saves the cost of down-time... keeps equipment producing.

It's easy to prove to yourself the value of concave sides

Simply bend a straight-sided belt (Fig. 2) and *feel* the bulge at the sides around the bend. You will quickly see why the bulging sides prevent an even fit in the pulley groove (Fig. 2-A). Uneven contact shortens belt life...increases belt costs.

Cut belt replacement time and costs...specify Gates Vulco Ropes—the V-Belt with *concave sides* (U.S. Pat. 1813698). The Gates Rubber Co., Denver, Colorado—*World's Largest Maker of V-Belts.*

Gates Engineering Offices and Distributor Stocks are located in all industrial centers of the United States and Canada, and in 70 other countries throughout the world.

TPA-30-A-C

GATES VULCO ROPE DRIVES

Flash butt-welding of mill-rolled sections will save $186,888.00 this year for one jet engine manufacturer

By designing the mill rolled section shown above, instead of using a rectangular bar, 98 lbs. of metal per ring was saved. The cost of fabricating rings was reduced $77.87 per ring.

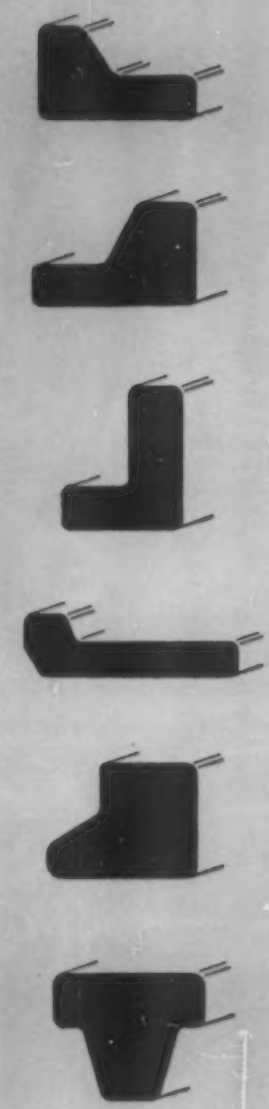
Are you using machined rings or bands? Rolling and flash butt-welding of special mill-rolled sections may be able to effect similar economies. Write today for complete information. Our Product Development Division will be glad to work with you.

THE AMERICAN WELDING & MFG. CO. • 140 DIETZ ROAD, WARREN, OHIO

AMERICAN WELDING

WELDING • MACHINING • FABRICATING

TYPICAL STAINLESS MILL ROLLED SECTIONS



Send for Free Catalog— of Production Facilities, 24-page booklet showing what American Welding can do for you.

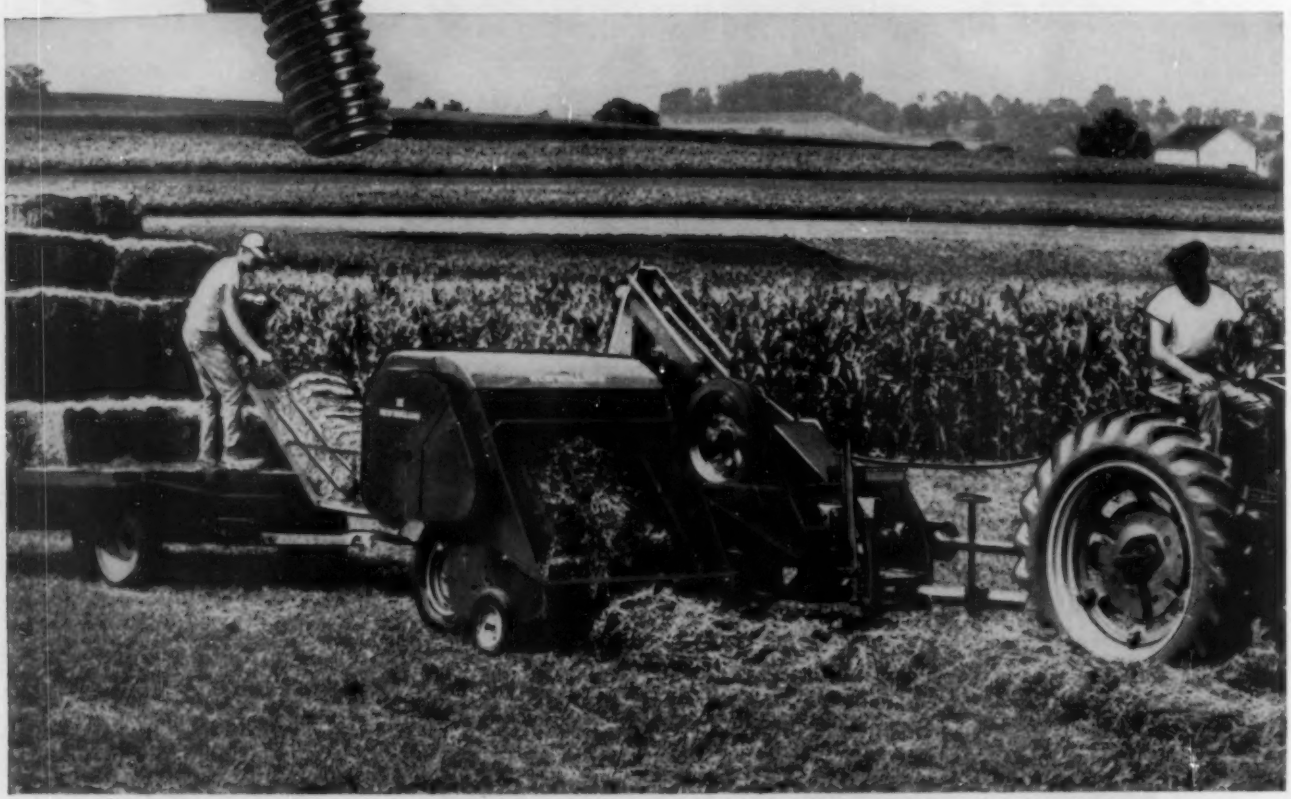
Here's a bolt whose weakness is its strength!

Making a bolt that fails precisely when it should requires specialized manufacturing skills.

This is the job New Holland Machine Company, farm equipment manufacturers, turned over to RB&W. The bolt is used on the flywheel of a New Holland baler. "Critical" is a weak word for its importance to the baler.

If the baler picks up a foreign object such as a rock or stone, this bolt *must* snap to prevent gear breakage. But it can't fail too soon—when the baler eats up extra-heavy windrows, for example. If it failed every time this happened, the farmer would spend all day replacing bolts — instead of making hay.

RB&W worked hand-in-glove with New Holland engineers in the tough job of heat-treating a standard machine bolt to these exacting specifications. It took a lot of ingenuity — but paid off. You can expect the same kind of service, cooperation and end product when you drop your fastener problem in our hopper. RUSSELL, BURDSALL & WARD BOLT AND NUT CO., Port Chester, N.Y.



UP TO TWELVE TONS OF HAY AN HOUR is the capacity of New Holland's Super 77 power take-off baler. With every minute vital in harvesting, farmers can't take chances on machinery failure — so New Holland built rugged parts into the Super 77, gave it extra-large capacity for fast, reliable operation.

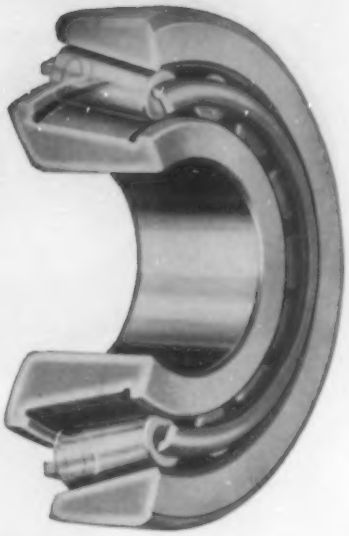
RB&W **RUSSELL, BURDSALL & WARD**

110 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG

Plants at: PORT CHESTER, N.Y.; CORAOPOLIS, PA.; ROCK FALLS, ILL.; LOS ANGELES, CALIF. *Additional sales offices at:* ARDMORE (PHILA.), PA.; PITTSBURGH; DETROIT; CHICAGO; DALLAS; SAN FRANCISCO. *Sales agents at:* NEW ORLEANS, DENVER, SEATTLE. *Distributors from coast to coast.*

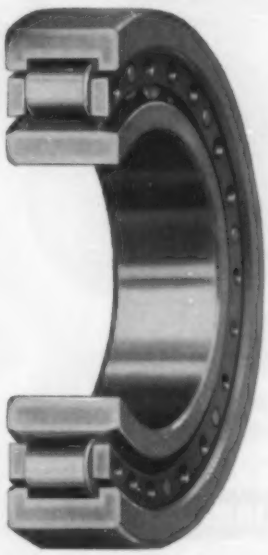
WHATEVER YOUR ROLLER BEARING APPLICATION

specify BOWER!



Earthmovers, jet turbine engines, rolling mill equipment, truck axles—you name it! Bower builds a complete line of tapered, straight and journal roller bearings including a size and type to fit *your* product. What's more, these dependable bearings have *proved* themselves in virtually every conceivable type of application. Their built-in quality, skillful engineering and advanced design features provide such important bearing advantages as reduced wear, longer life and lower maintenance requirements. Let a Bower engineer give you full details on the complete Bower line.

BOWER ROLLER BEARING COMPANY
DETROIT 14, MICHIGAN



BOWER TAPERED ROLLER BEARINGS INCORPORATE ADVANCED SPHER-O-HONED DESIGN! Spherically generated roll heads and higher flange with larger, two-zone contact area reduce wear, improve roller alignment and virtually eliminate "end play." This helps hold adjustment and pre-load longer and better. Larger oil groove provides positive lubrication.

BOWER STRAIGHT ROLLER BEARINGS ARE BUILT TO CARRY MAXIMUM LOADS! Integral two-lip race increases rigidity—keeps rollers in proper alignment at all times. Steel cage allows free movement of rollers between races during normal operation. High-grade alloy-steel rollers and races are precision-ground for quieter, smoother operation.

A COMPLETE LINE OF TAPERED, STRAIGHT AND JOURNAL ROLLER BEARINGS
for every field of transportation and industry

BOWER

SPHER-O-HONED

ROLLER BEARINGS

...and Always to Your Exact Specifications!

Western Felts are highly versatile! That's one of their tremendous advantages wherever you can use a felt component to help the performance of your product. We start with the very picking and carding of the millions of tiny wool fibres, with every process in our plant under our complete control!

Western Felts are made soft and springy, dense and hard, or of any of the unlimited degrees of density in between. They are conditioned for the exact jobs they are to perform, right down to the precision cutting to extremely close tolerances. Especially in the more dense consistencies, tolerances often are as close as a few-thousandths of an inch!

Wear, age and weather do not affect Western Felt parts. They deaden sound, seal against dust, greases and oils, or they are made to absorb and feed oil when used for lubrication...*exactly* as you wish. Western Felt parts can be chemically treated for hardness, waterproofing, mothproofing, oil retention, abrasion resistance...or greater tensile strength.

Western Felt components will help solve many of your problems. You are invited to consult with our engineers.

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MANUFACTURERS AND CUTTERS OF WOOL FELT

AMP TERMINALS for ALUMINUM wire #8 to 3/0

TERMALUM Terminals

A-MP TERMALUM Terminals overcome problems inherent in aluminum wire termination. All-aluminum TERMALUM Terminal has "cartridge" pre-loaded with special oxide removing and inhibiting compound. Confined crimp extrudes wire strands evenly and eliminates hot spots. During crimping, inhibitor is forced among strands and between insulation and terminal to form moisture barrier. The TERMALUM Terminal is suited for high ambient temperature and heavy current cycling applications. *Far exceeds all Military Specifications.*

COPALUM Terminals

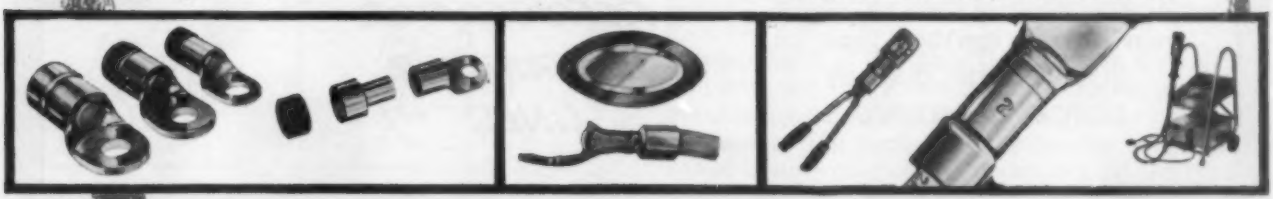
A-MP COPALUM Terminals are a new approach to termination of aluminum conductors. Has same "cartridge" construction as TERMALUM Terminals, but body is made of tin plated copper. Smaller tongue sizes are permissible with COPALUM, but TERMALUM is recommended where frequent temperature cycling above 130° C. prevails, and constant ambient temperature is above 100° C. *Exceeds Military Specifications.*

A-MP TERMALUM and COPALUM Terminals are available in wire size 8 to 3/0. Exploded view shows "cartridge" construction. Cartridge (center) fits in barrel (right). Color coded cap (left) retains inhibitor in cartridge until used.

Cross section shows evenly deformed strands and large contact areas of wires and terminal body.

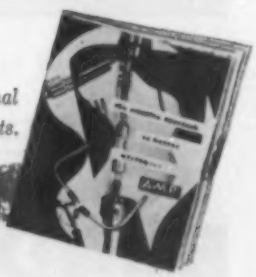
Longitudinal view shows cartridge sealed at wire end and insulation supporting crimp

A-MP TERMALUM and COPALUM are applied with A-MP DYNA-CRIMP or Hand Hydraulic Tools. DYNA-CRIMP can be bench or cart mounted. Air-electric or foot Pump actuations are available with DYNA-CRIMP. DYNA-CRIMP is for wire sizes 8 to 3/0 and A-MP Hand Hydraulic is for wire sizes 8 to 4. Wire size is embossed on terminal during crimping. (SEE CLOSE UP.)



Another example of AMP's Creative Approach to Better Wiring

Write today for additional information on these products.



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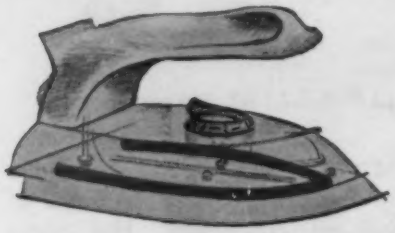
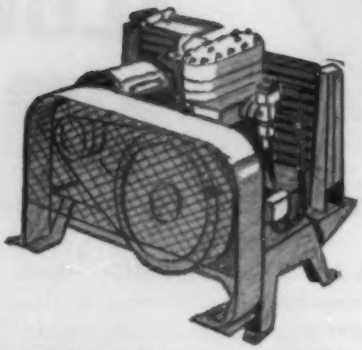
BUNDY TUBING COMPANY

FROM *the Bundy Sketchbook*
TO *jog a designer's imagination*



SHEATH FOR HEATING ELEMENT IN HAND IRON



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REMARKS Designing a new product? Or redesigning an old one? Why not avoid delays, expense by turning your tubing headache over to our engineering experts. They offer you a wealth of problem-solving experience, plus the priceless bonus of Bundyweld, the only tubing double-walled from a single strip (see below).

WRITE today for catalog or for help in developing your tubing application.

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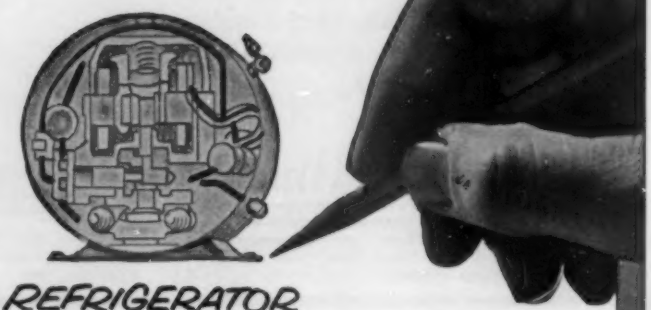

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WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness,

and passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

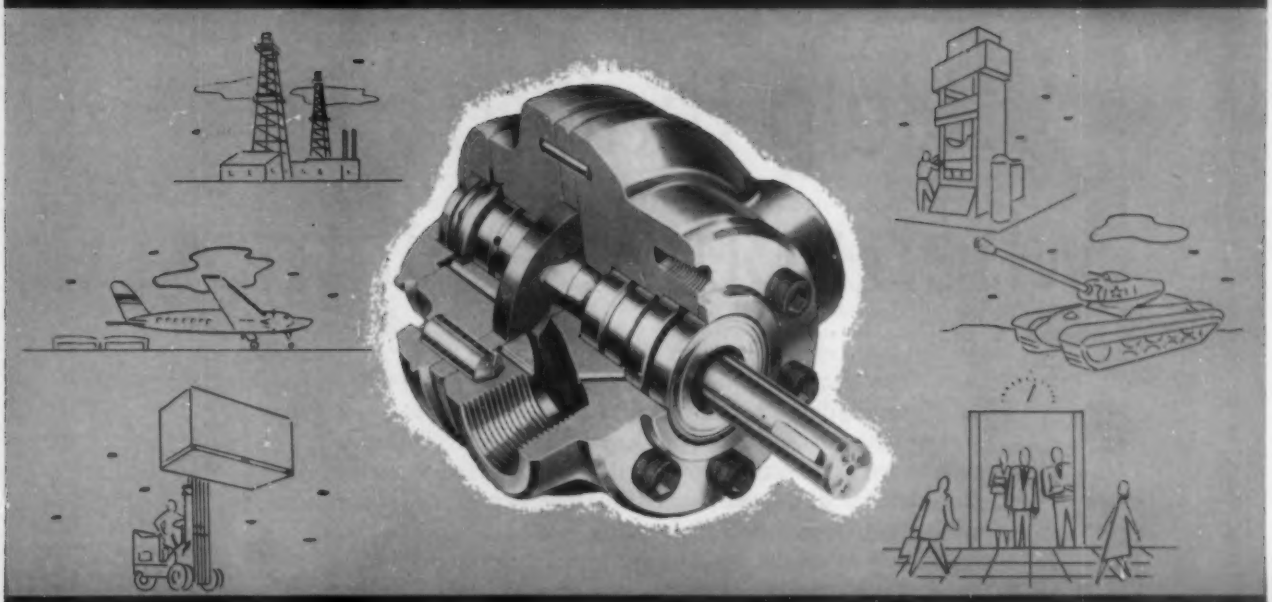
BUNDYWELD TUBING®

DOUBLE-WALLED FROM A SINGLE STRIP

Leakproof	Lightweight
High thermal conductivity	Machines easily
High bursting point	Takes plastic coating
High endurance limit	Takes plating
Extra-strong	Bright and clean
Shock-resistant	No inside bead
Ductile	Uniform I.D., O.D.

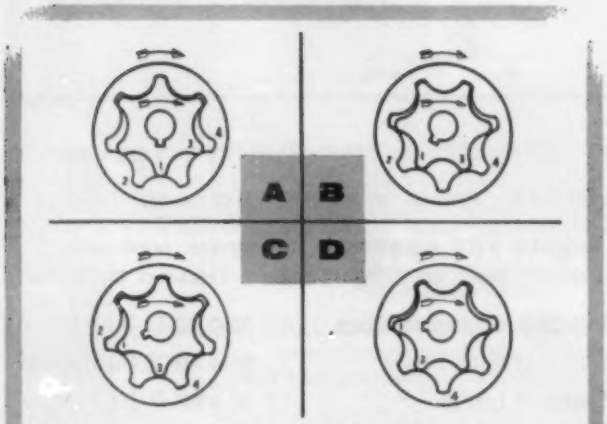
Bundy Tubing Distributors and Representatives: *Cambridge 42, Mass.:* Austin-Hastings Co., Inc., 226 Binney St. • *Chattanooga 2, Tenn.:* Poirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • *Chicago 32, Ill.:* Lapham-Hickey Co., 3333 W. 47th Place • *Elizabeth, New Jersey:* A. B. Murray Co., Inc., Post Office Box 476 • *Los Angeles 58, Calif.:* Tubesales, 5400 Alcoa Ave. • *Philadelphia 3, Penn.:* Rutan & Co., 1717 Sansom St. • *San Francisco 10, Calif.:* Pacific Metals Co., Ltd., 3100 19th St. • *Seattle 4, Wash.:* Eagle Metals Co., 4755 First Ave., South *Toronto 5, Ontario, Canada:* Alloy Metal Sales, Ltd., 181 Fleet St., E. • **Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.**

Gerotor Hydraulic Pumps are...



Designed to take it!

Gerotor's simple design and sturdy construction assures longer, trouble-free life for your hydraulic system!



The two Gerotors revolve at different speeds, resulting in a continuous opening and closing of the spaces as shown in this diagram. Follow the changing position of tooth #1 as rotation takes place. Note its relation to space #2. As rotation continues, tooth #1 gradually displaces oil from space #2, thus creating pressure. The outer rotor of the Gerotor principle is designed with one tooth more than the inner rotor, with fluid-tight contact at all points. As a result, low tooth sliding velocity is achieved.

Friction is the basis for all wear . . . Gerotor's exclusive rotor design cuts friction to a minimum. The Gerotor principle . . . heart of every Gerotor pump . . . is represented by a pair of gear-shaped elements, one within the other. Power is applied through the shaft to the inner Gerotor and is transmitted in the closed mesh region to the outer Gerotor.

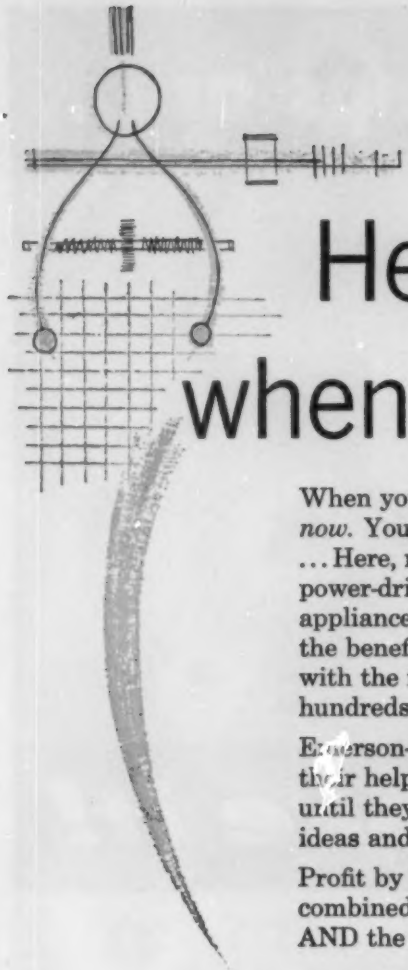
Each tooth of the inner Gerotor is in sliding contact with the outer Gerotor at all times, providing continuous fluid-tight engagement at very low contact speed. The contact points revolve only once in seven to nine revolutions, depending on the type of unit. ***This reduced friction permits higher shaft speeds, assures longer life.***

Due to high production facilities, Gerotor can produce special pump designs in *quantities* at an amazingly low price. Whatever your hydraulic pump problems, bring them to Gerotor.

FREE literature available . . . write:

GEROTOR MAY CORPORATION

1511 Maryland Avenue . . . Baltimore 3, Maryland



Help that counts when you need it most...

When you need help with any power-drive problem, you need it *now*. You get this timely help—and more—from Emerson-Electric ... Here, ready to serve you at a moment's notice, is a group of power-drive specialists who know motors AND the needs of appliance and equipment manufacturers. These men can give you the benefits of 64 years' accumulated experience, beginning in 1891, with the first motor for a sewing machine, and covering hundreds of appliance and equipment applications.

Emerson-Electric specialists are ready to serve you when you need their help. They are always on call. You don't have to wait until they "get around to it." They will start with your design ideas and follow through to final test and application runs.

Profit by Emerson-Electric's years of experience and the combined ability of its motor specialists. They know motors AND the appliance-equipment business.

EMERSON-ELECTRIC SUPPLIES MOTORS FOR APPLIANCES AND EQUIPMENT IN THESE CLASSIFICATIONS

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Medical
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Office
Printing and Typesetting
Pump
Recording
Refrigeration
Scientific
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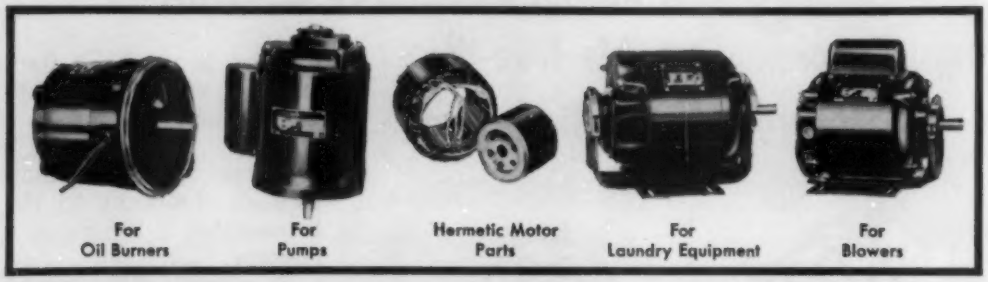

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Or, write THE EMERSON ELECTRIC MFG. CO., ST. LOUIS 21, MO., for Bulletins listed below

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- ☐ M 4003-C Integral
- ☐ M 4003-D Fan Duty
- ☐ M 4003-E Oil Burner
- ☐ M 4003-F Jet Pump
- ☐ M 4003-G Blower

Emerson-Electric

of St. Louis • Since 1890

A Good Team to Team with

...BEFORE FREEZING YOUR NEW MODEL DESIGNS FOR PRODUCTION

Tomorrow's equipment will have to run faster, work harder, last longer. The new product you may now have under development is probably no exception. That's why you are giving it the design forethought that will assure improved performance and longer trouble-free life. And that's just where Aetna is uniquely qualified to help.

With nearly forty years of experience in designing special bearings and parts for volume production, our engineers can be of real assistance to your own design department . . . can assure you the consistent quality and extreme uniform accuracy that speeds assembly, cuts costs, improves product serviceability and saleability. Your inquiry will receive our immediate attention.

Aetna

AETNA BALL AND ROLLER BEARING COMPANY

DIVISION OF PARKERSBURG-AETNA CORPORATION

4600 Schubert Avenue • Chicago 39, Illinois

Standard and Special Ball Thrust Bearings • Angular Contact Ball Bearings • Special Roller Bearings • Ball Retainers • Hardened and Ground Washers • Sleeves • Bushings • Miscellaneous Parts

SHELL MOLDED CASTINGS

GIVE *Smooth* AS-CAST SURFACES

INSTEAD OF

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ALUMINUM
COPPER
BRASSES
BRONZES
CAST IRON
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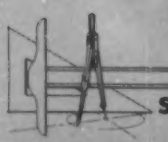

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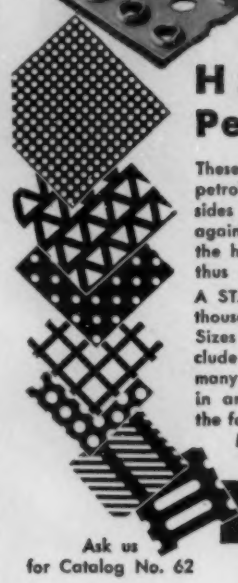

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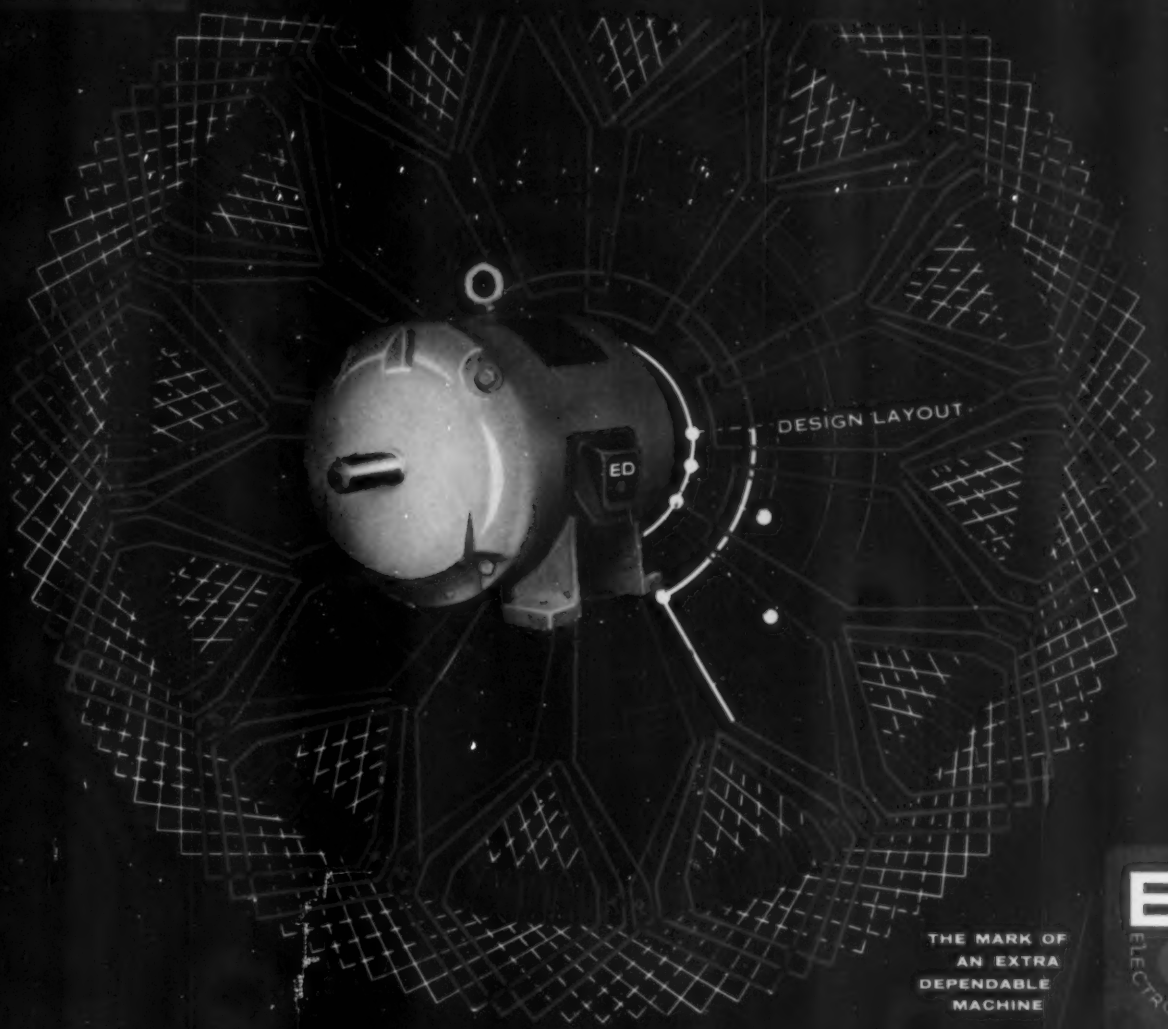

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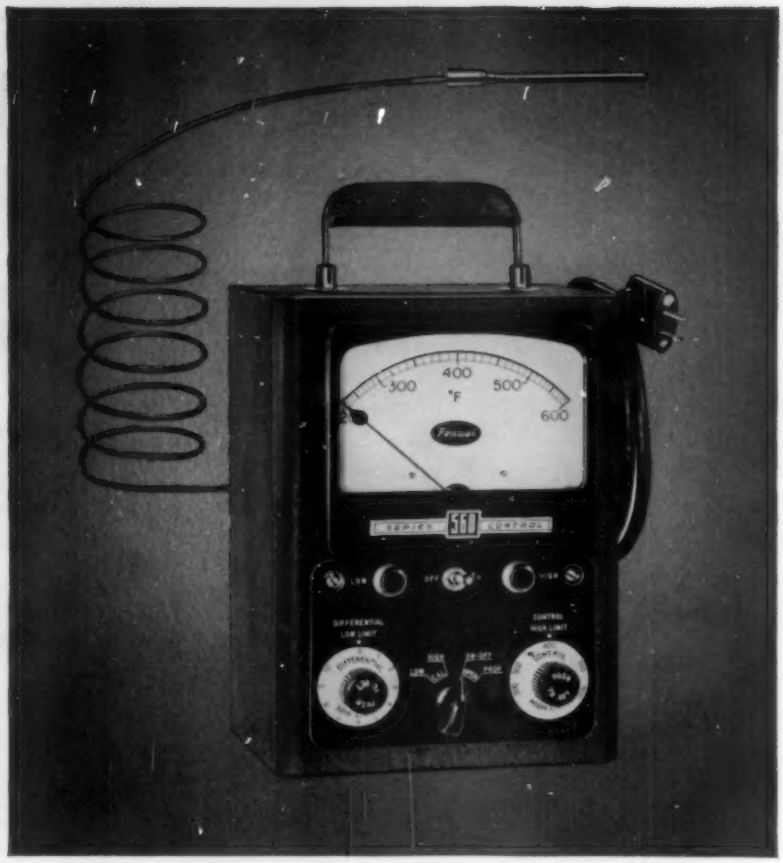

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DESIGNING WITH ALUMINUM

NO. 11

This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series will be supplied on request. Address: Advertising Department, Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

COMBATING CORROSION

ALUMINUM is widely recognized as a light weight material of construction having good mechanical properties and excellent resistance to corrosion. With industry placing increased emphasis on longer equipment life, and therefore on less rapid corrosion deterioration, there has been a strong trend toward replacing less corrosion resistant metals with aluminum alloys. To obtain the fullest benefits from these changes in materials of construction, each installation should be properly designed from the corrosion standpoint so that maximum service life can be obtained.

Why Aluminum Is Corrosion Resistant

Corrosion is essentially the reversion of a metal to its ore under the influence of natural weathering and other accelerating factors. Aluminum owes its comparative immunity to corrosion to the formation of a thin invisible coating of oxide which forms very rapidly over its surface. This oxide is kept in constant repair by the atmosphere, and it usually affords a very high degree of protection to the metal in all except the most corrosive of environments. However, in extremely corrosive environments the protection given by the oxide film may not be quite enough to prevent corrosion completely, and small white deposits of hydrated aluminum oxide may form at weaker places in the surface film. Even here, however, the attack on the metal rapidly comes to a virtual halt due to the additional protection afforded by the corrosion products themselves. Table 1 shows the small decreases in mechanical properties of aluminum alloys exposed to rural, industrial and marine atmospheres for a ten year period.

TABLE 1

RESISTANCE OF WROUGHT ALUMINUM ALLOYS TO CORROSION BY NATURAL ENVIRONMENTS

% Change in Tensile Strength Resulting from Ten Year Tests

Alloy	ATMOSPHERE		
	Rural	Industrial	Marine
1100-H14	−3	−6	−3
3003-H14	−1	−5	−1
2024-T3	−3	−7	−7
Alclad 2024-T3	+2*	+1	+2

** Increase in mechanical properties is due to ambient temperature age hardening*

Data based on information published in ASTM Symposium on Atmospheric Exposure Tests on Non-Ferrous Metals published February 27, 1946.

How to Design for Maximum Corrosion Resistance

The test results shown in Table 1 clearly reflect the excellent corrosion resistance of flat panels of aluminum alloys. However, any highly resistant material of construction will never give the maximum service in a poorly designed structure. Some methods of insuring good design from the corrosion standpoint are outlined below:

Avoiding Crevice Corrosion and Liquid Entrapment Inaccessible places such as sharp re-entrant angles are ideal places for the accumulation of solids and for liquid entrapment. Under such conditions it is difficult for oxygen to circulate freely and repair any damage to a protective oxide film. These places are, therefore, potential trouble spots with even the most highly corrosion resistant metals. Sharp corners must be avoided wherever possible (Fig. 1).

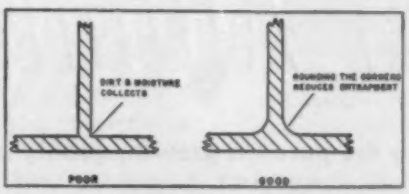

Fig. 1. Reducing entrapment by rounding sharp corners greatly improved corrosion behavior.

In equipment involving the use of liquid solutions, adequate facilities must be provided to insure complete drainage (Fig. 2).

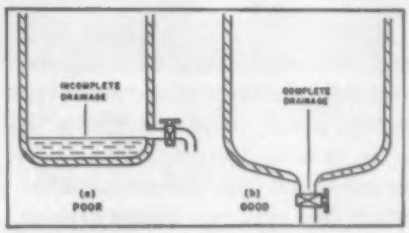

Fig. 2. Design to improve drainage and enhance corrosion resistance.

Welded connections should be used instead of bolting or riveting, and butt welds are definitely preferable to lap welds (Fig. 3).

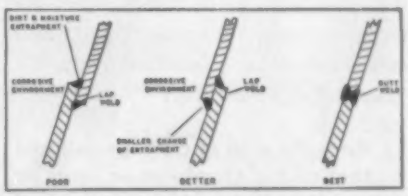

Fig. 3. Design of welded joints from the corrosion standpoint.

Where a bolted connection is mandatory, the crevices should be sealed wherever possible by a mastic compound or by weld metal.

Heat exchangers should be designed to give smooth, non-turbulent flow with a minimum of air entrainment and should be provided with suitably located strainers in the cooling lines to prevent the build-up of deposits at unavoidable local obstructions.

PLEASE TURN TO NEXT PAGE

Every effort should be made to prevent the accumulation of dirt and insoluble matter on aluminum structures. Such deposits and poultice-like material will frequently be the sites of unnecessary corrosion. Low pitch aluminum roofs should be avoided in areas of low rainfall where the washing action of the rains is insufficient to remove wind-blown deposits. Under these conditions a regular hosing down of the structure will greatly extend its service life.

Avoiding Galvanic Corrosion Galvanic corrosion of aluminum in contact with some dissimilar metals can be a serious hazard in a corrosive environment. In most cases, aluminum will suffer accelerated corrosion while partially or completely protecting the other metal.

Clearly, the best way to design around this problem is to make the equipment entirely of aluminum alloys. Where this is impossible, consideration must be given to using dissimilar metals, such as galvanized iron and stainless steel, which show only very limited galvanic activity with aluminum. In most environments contact with these two products is not harmful to aluminum.

However, direct contact with copper, brasses, bronzes and steel can stimulate the corrosion of aluminum to an undesirable level, particularly in marine environments. This type of corrosion can be reduced or eliminated by the following design measures:

1) Keep the area of copper small and that of the aluminum as large as possible. This reduces the overall corrosion and reduces its intensity by spreading it out.

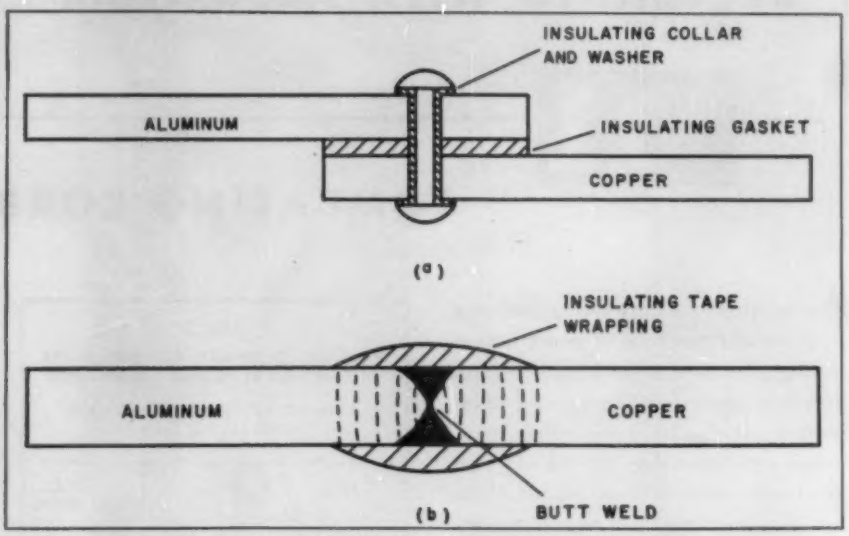

Fig. 4. Methods of insulating dissimilar metals to prevent galvanic corrosion

2) Paint or protect both the aluminum and the copper or the copper alone. Under no circumstances protect the aluminum alone, because the intensity of corrosion at any discontinuity in the protective coating will be very high.

3) Wherever possible, insulate the copper from the aluminum by insulating gaskets or by wrapping with tape as shown in Figure 4.

Avoiding Stress Corrosion and Corrosion Fatigue Since most aluminum alloys have high resistances to stress corrosion and to corrosion fatigue, proper design practices in operating equipment can further reduce these corrosion hazards to an almost non-existent level. Proper design to prevent both types of corrosion consists of minimizing the stress levels in the equipment. This may be achieved by avoiding stress raisers such as sharp radius bends, small radius fillets, crevices and notches. Residual stresses should be reduced wherever possible by insuring accurate fitting of assemblies, while members carrying the highest design loads can be made extra thick. In this way stresses may be kept to a minimum and the maximum service life can be attained.

The design practices outlined above represent those most commonly applied to obtain the highest degree of corrosion resistance from aluminum equipment. More detailed assistance with design and alloy selection may be obtained through the Kaiser Aluminum sales office listed in your telephone directory, or through one of our many distributors. Kaiser Aluminum & Chemical Sales, Inc. *General Sales Office:* Palmolive Bldg., Chicago 11, Ill.; *Executive Office:* Kaiser Bldg., Oakland 12, California.

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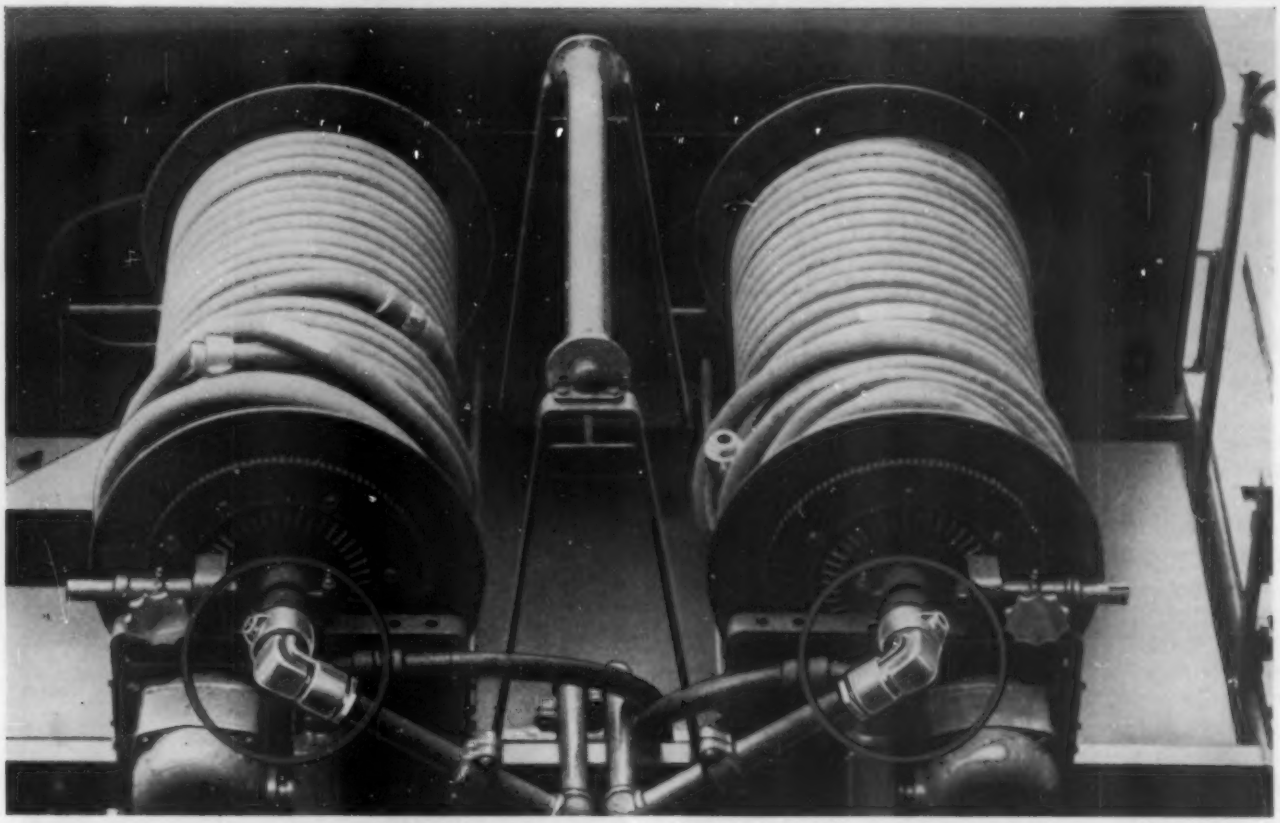


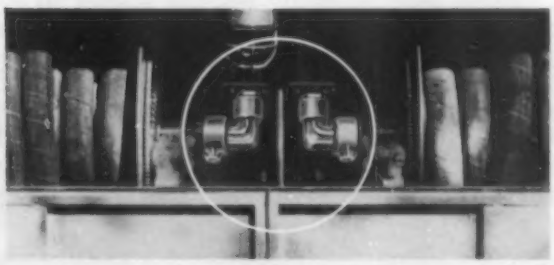
Twin Hannay hose reels on this fire truck, with explosion-proof motors, employ Chiksan swivel joints. These joints will handle foam, or other chemicals used in fire fighting.

CHIKSAN swivel joints solve hose reel connection troubles

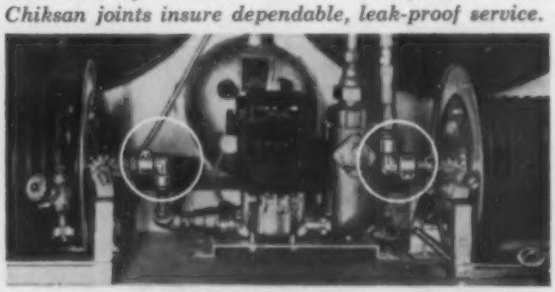
One of the troublesome problems of hose reel operations is leaky, hard-turning revolving connections. Leading manufacturers of hose reels have licked this problem by standardizing on Chiksan ball-bearing swivel joints for their critical applications.

For the past seven years, Hannay, one of the leaders in the hose reel field, has used Chiksan swivel joints on their hose reels for all types of industrial purposes. Chiksan ball-bearing swivel joints offer the advantages of a dependable balanced sealing unit, free turning, and a simplified design which requires a minimum of maintenance. Moreover, Chiksan offers a complete line of hose reel swivel joints with, or without, mounting pads, in sizes from 1" thru 2" in various styles and metals.

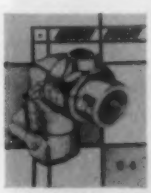
Wherever liquid or gas must flow with safety, speed and economy, Chiksan ball bearing swivel joints can be relied upon to do the job efficiently with the minimum amount of maintenance and cost. Make sure your hose reels have Chiksan ball bearing swivel joints.



Refueling planes with high octane aviation gas is a hazardous operation. On these Hannay hose reels, Chiksan joints insure dependable, leak-proof service.



In handling the highly volatile L.P. gas, Hannay uses Chiksan style 30 swivel joints to provide complete safety and flexibility on their hose reel assemblies.



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Quality is improved for many reasons... greater control of production and materials, closer tolerances, specialized steels in each part of the unit for specific requirements, more accurate heat treating results, greater uniformity throughout.

Costs are reduced, too, for varying reasons... sometimes because of the increased production possible by combining stampings and machined parts through brazing... or because material is saved because of the efficiency of brazed production... perhaps the savings are because the utilization of B-N facilities obviated installation of costly equipment, or because Burgess-Norton, one of the pioneers in production hydrogen-copper brazing, has gained valuable experience and knowledge that saves the customer through the total of many small efficiencies.

Brazed assemblies are not the answer to every parts problem, certainly, but they are being employed with advantage in more and more instances. If component parts are required in your production picture, we sincerely believe it will pay you to check with Burgess-Norton. Your inquiry will be handled promptly. If you prefer, a sales representative will call at your convenience.

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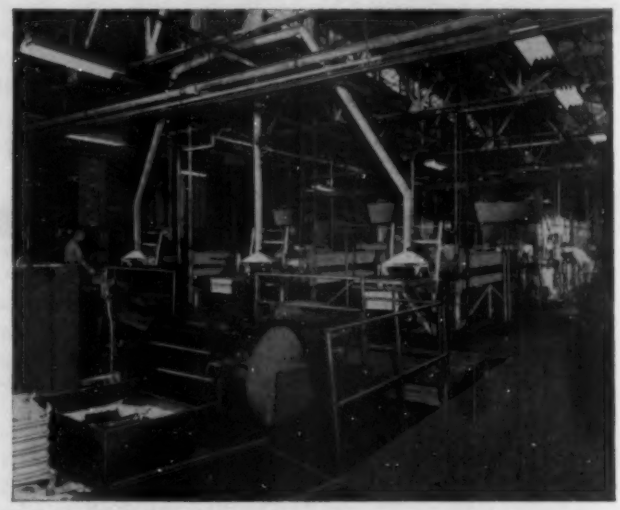
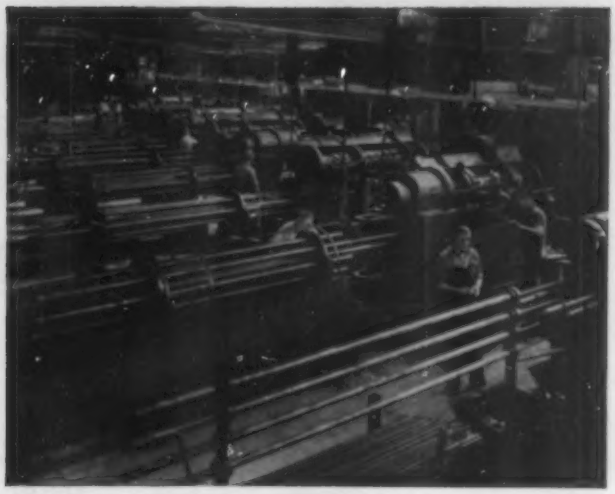


The exceptional B-N heat treating facilities include both batch type and continuous fed atmosphere controlled furnaces, as well as induction heating. Burgess-Norton was one of the earliest firms to employ large scale induction heating for the treatment of metal.

Production of many of the brazed assemblies begins in the stamping department. By combining stampings and machined parts through hydrogen-copper brazing, B-N effects considerable savings in production and at the same time improves performance of the part.



This partial view of the Burgess-Norton screw machine department shows only a few of the basic machines employed in parts production. Facilities include machine tools for all secondary operations, plus a complete tool room.

These assemblies are representative of the many different parts problems that are being solved for industry by B-N engineering, production facilities and experience.

Firm in the knowledge that good parts begin long before actual production, Burgess-Norton maintains a large staff of engineers and an unusually complete metallurgical laboratory. These engineers, experienced in parts redesign for modern production methods, have been a major factor in the B-N "better parts at lower costs" story.

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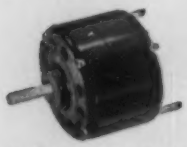

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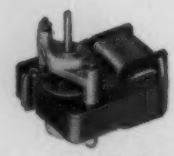

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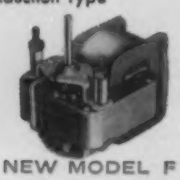

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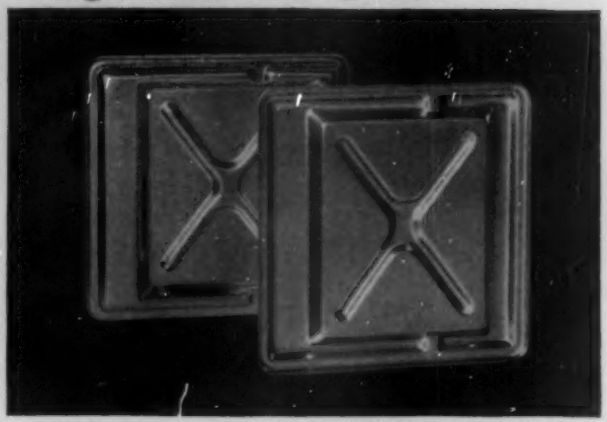

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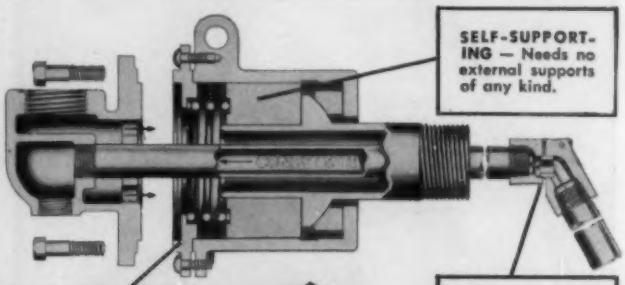
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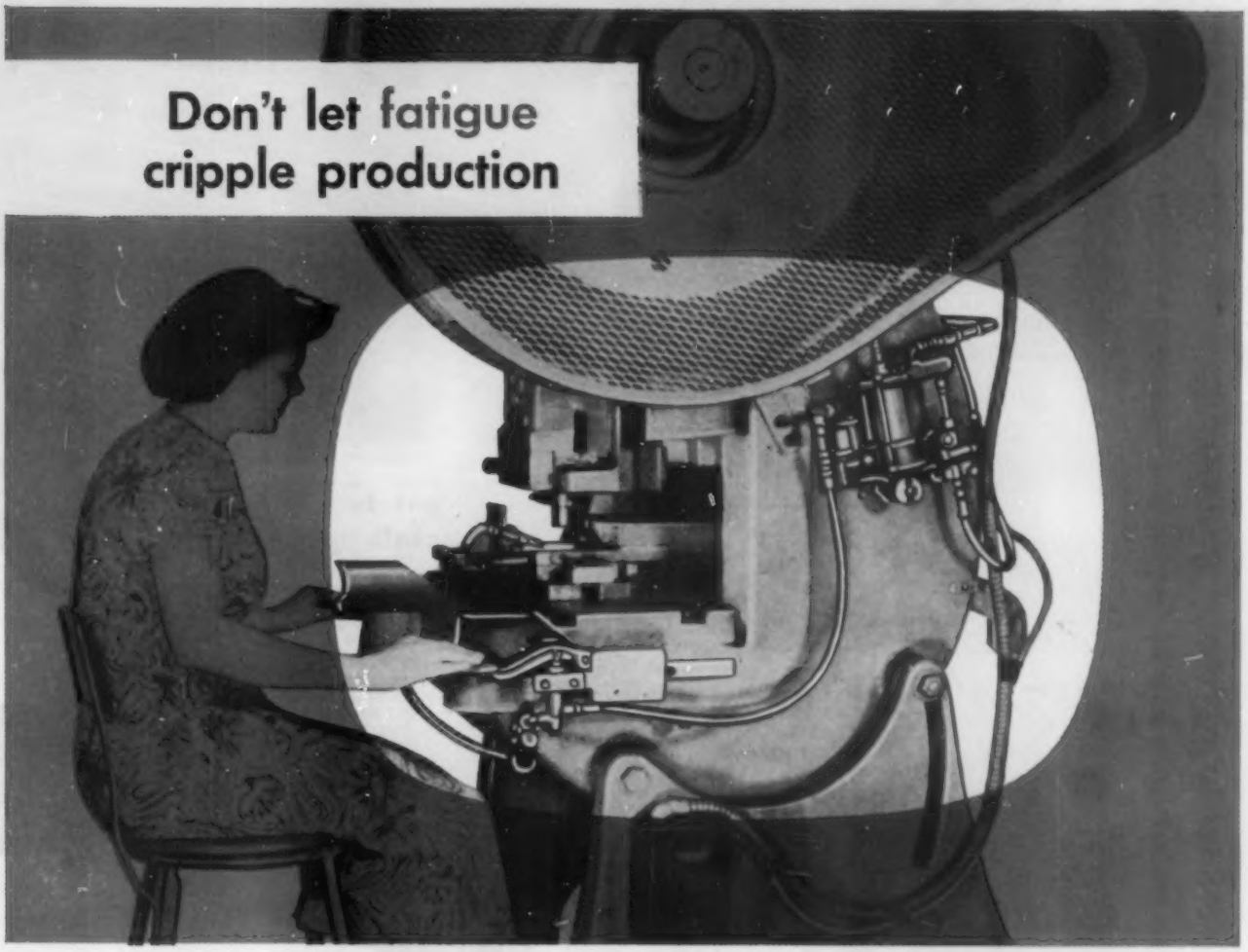

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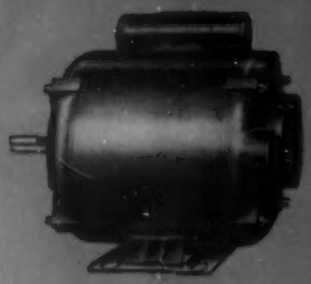

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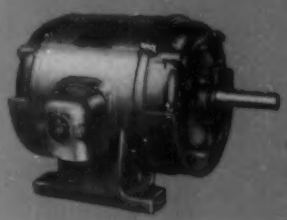

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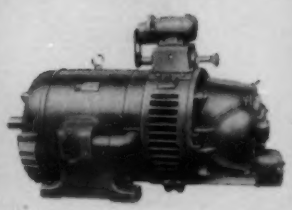
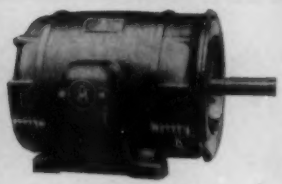
Explosion-Proof

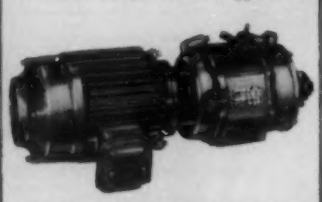


(Schrage) Variable Speed



Type C-Face Mounted

Vertical Solid Shaft—Type P



Sadivar Variable Speed Motor

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Linde FLAME-PLATING NEWS

News of another successful use of LINDE'S process for applying a tungsten carbide coating to metal parts.

Flame-Plated plug, ring, and air gages have extra-high wear resistance for long-lasting accuracy.

Flame-Plated Plug Gages Outwear Carbide Gages 3-1... Hard Chrome Plated Gages 20-1!

Flame-Plating, a LINDE Service for depositing a thin coating of hard, wear-resistant tungsten carbide on metal parts and many tools, continues to be used with highly successful results on plug, ring, and air gages. The wear-resistant tungsten carbide coating, applied in LINDE's Flame-Plating plant, gives gages lasting accuracy through a longer wear life. Flame-Plated plug gages, for example, have actually outworn solid sintered tungsten carbide gages 3 to 1...hard chrome plated gages 20 to 1.

TEMPERATURE COMPENSATION PROBLEMS REDUCED

Flame-Plated gages have the same coefficient of thermal expansion as the gage base metal. When the gage base metal is similar or identical to the part being gaged, temperature compensation problems are either greatly reduced or eliminated entirely.

CHIPPING AND BREAKAGE PRACTICALLY ELIMINATED

Flame-Plating a gage with tungsten carbide produces a hard, wear-resistant surface while retaining the toughness of the base metal. Thus, the problem of breakage is greatly minimized especially on small diameter gages. The tungsten carbide coating is also highly resistant to chipping. These factors are important advantages over solid sintered carbide gages.

AVAILABLE NOW AT LEADING GAGE SUPPLIERS

Flame-Plated plug, ring, and air gages are now available in standard AGD sizes. Plug gages from .059-in. up. Ring gages from .375-in. up. Ask your gage supplier how you can cut inspection costs with Flame-Plated gages or call the LINDE office nearest you. Send for your free copy of the Flame-Plating booklet today.

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Kraissl Class 72 duplex separators are designed so that you don't need to use a lifting jack to raise the rotary plug valve. The valves are designed to a sufficiently wide angle taper — so that the plug does not wedge on its seat, through wear and use.

Grit, scale and extraneous abrasive matter settle on the seat face, from using a lifting jack. Then, when the plug is returned to its seat and the valve rotated, the seat is galled and scored. This terminates the serviceable life of your separators —and skyrockets your maintenance and overhaul costs.

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Bulletin A-1214 gives full data —write for your copy today!

KRAISSL KRAISSL CO

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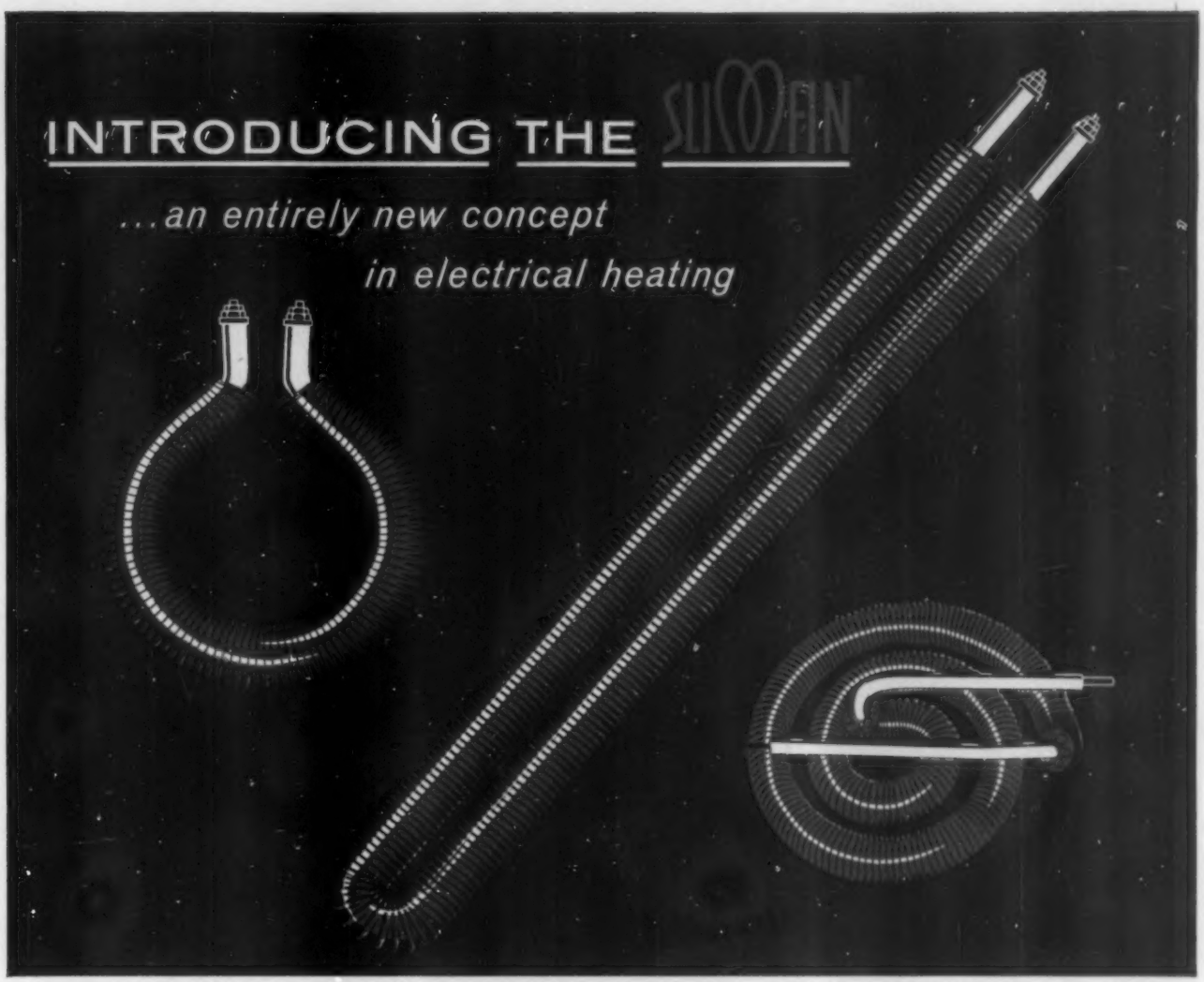

Small! Compact! Easily shaped for any area!

It's *small,* less than an inch in diameter—with $1\frac{5}{16}$" steel fins copper-brazed on a .312" steel-sheath rod-type heater.

It's *compact,* provides maximum heat dissipation in any space, gives you new freedom in design of products.

It's *easily shaped* to fit any area because the forming is done before the spirally wound fins are attached. Yes, the steel fins are *spirally wound* and securely brazed to the rod. And you can have from *four* to *eleven* fins to the inch in spacing, to provide exactly the heat dissipation you need for any given application.

Like all *Ferrod* heaters, these new Slimfin Units are made from high-grade resistors embedded in refractory insulation inside a length of tubing — in this instance, steel tubing. Precision made, they are designed for natural convection space heating. Capacities range from 500 to 2,000 watts.

Heavy-duty heaters are made in this same style, with .540" tubing and $1\frac{5}{16}$" diameter fins, for forced convection air heating. Capacities range from 1,000 to 10,000 watts.

Write for catalog sheets giving sizes, wattages and other detailed information. It will help us to *help you* if you tell us the application you have in mind.

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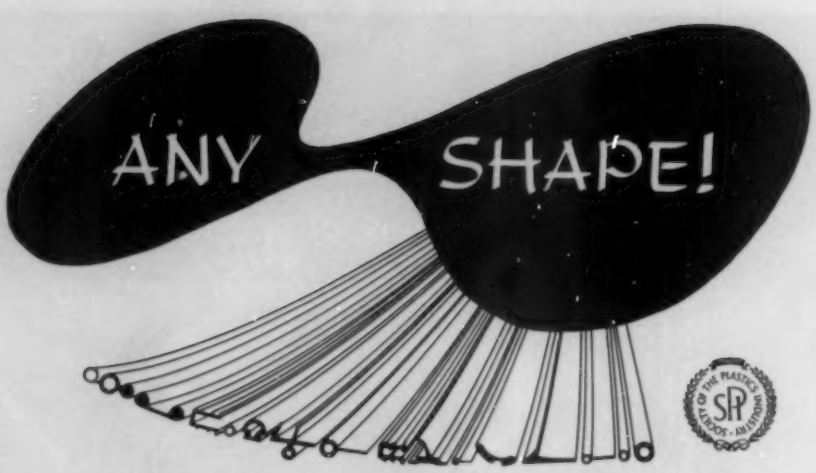

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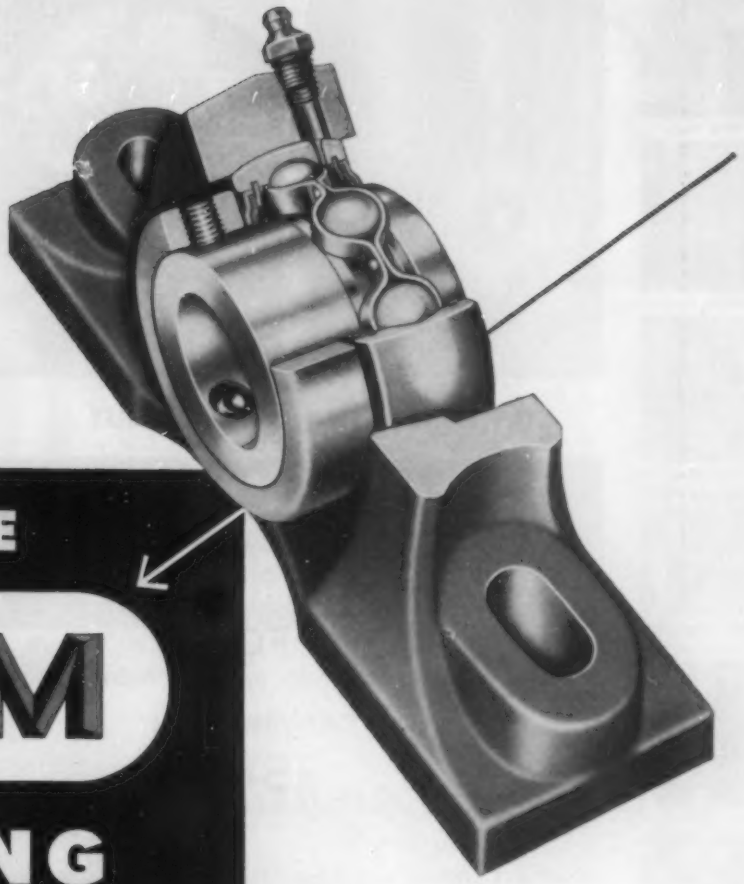
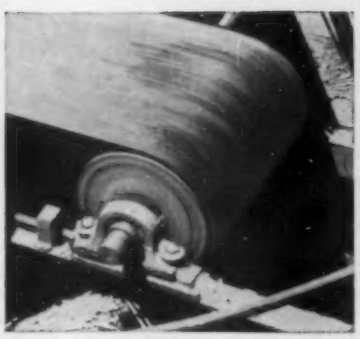


DODGE

SCM

BEARING

A wonderful new Ball Bearing Pillow Block by Dodge . . . for *medium* duty!



More load-carrying capacity . . . larger shaft sizes . . . plus all the features and dependability of the famous S C Ball Bearing line! These are the qualities provided in Dodge S C M, a new line of mounted ball bearings, available in both pillow blocks and flange cartridge type.

Designed for medium duty, these new bearings are of heavier construction, with complete new housings. Metallic-backed Neoprene seals keep lubricant in, dust and dirt out of the bearing. Engineered to stay put, *the seal won't blow!*

S C M bearings are new members of the famous Dodge 30,000 hour line, all of which are sealed, both on and off the shaft. Fully assembled and pre-lubricated at the factory, they are ready to slip on the shaft. Available from Distributors' stocks in shaft sizes from 1-7/16" to 3-7/16".

Write for bulletin with complete specifications.

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of Mishawaka, Ind.

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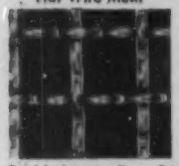
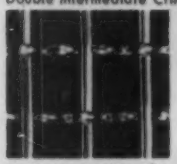
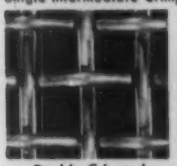
Flat Wire Mesh

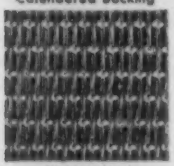

Double Intermediate Crimp

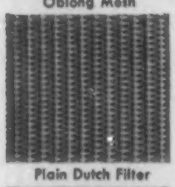

Single Intermediate Crimp

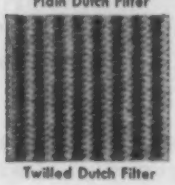

Double Crimped

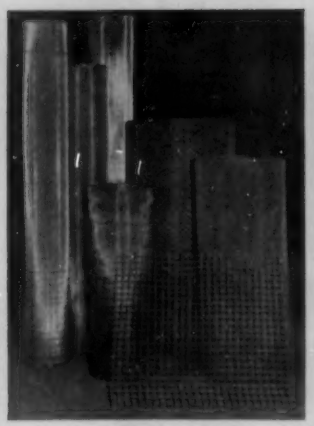
Twilled Weave

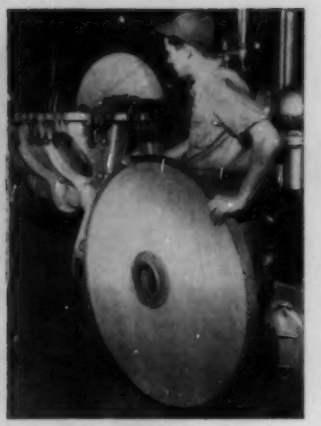
Calendered Backing


Oblong Mesh


Plain Dutch Filter


Twilled Dutch Filter





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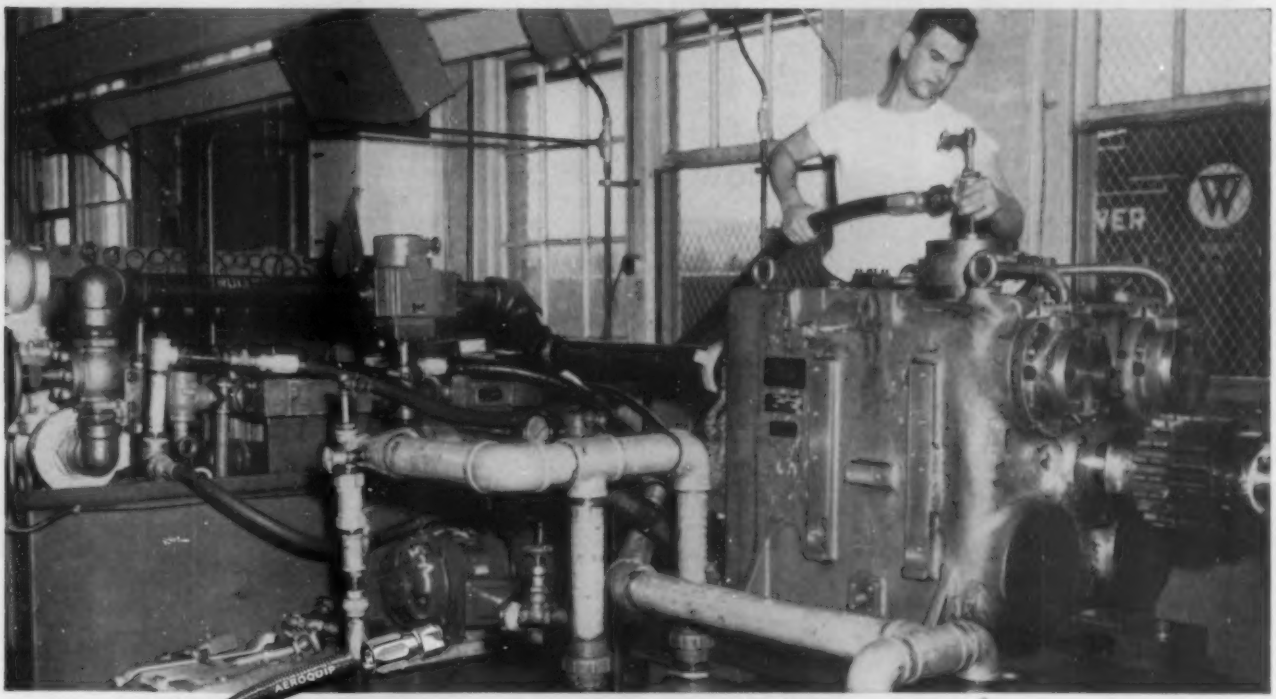
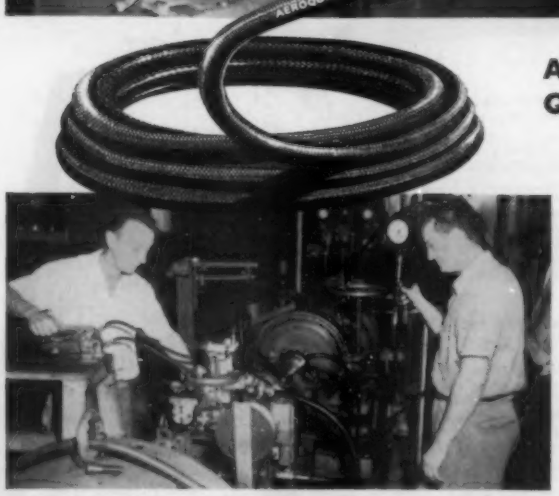
"Our Test Stand Hook-Up Time Has Been Reduced From Days To Hours"

SAYS HENRY LEGERE, *Hydraulic Test Foreman, Waterbury Tool Division of Vickers Incorporated*





Size 5 heavy duty transmission for cargo winch drive shown in a typical test stand hook-up. Notice how Aeroquip flexible hose lines are used to eliminate need for alignment.

AEROQUIP FLEXIBLE HOSE LINES INSTALL QUICKLY... ELIMINATE ALIGNMENT PROBLEMS

Pressures as high as 5,000 p.s.i. are encountered in the testing of hydraulic equipment produced by Waterbury Tool Division of Vickers Incorporated, Waterbury, Conn. Aeroquip hose lines meet all performance requirements, and make it possible for laboratory personnel to make test stand installations quickly and easily.

Henry Legere, Test Stand Foreman, reports that one installation, normally requiring four hours to form and fit piping, is accomplished in *5 minutes* when Aeroquip hose lines are used!

A supply of Aeroquip bulk hose and reusable fittings will help you three ways: (1) Cut inventory because you can make Aeroquip hose lines to required length in minutes; (2) Cut installation time because all alignment problems are eliminated; (3) Eliminate failures because Aeroquip hose lines are exceptionally tough and durable.

Write for complete information.

Aeroquip

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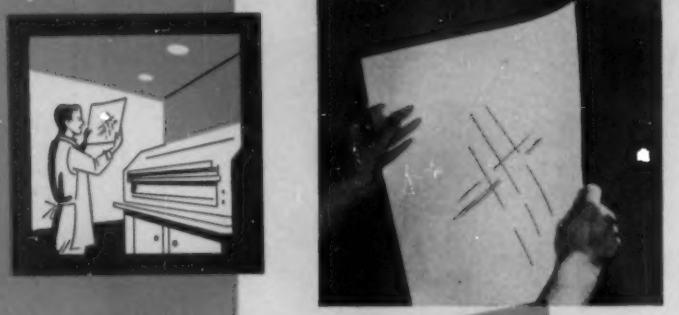

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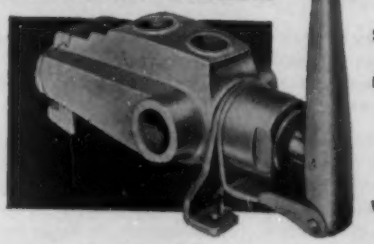
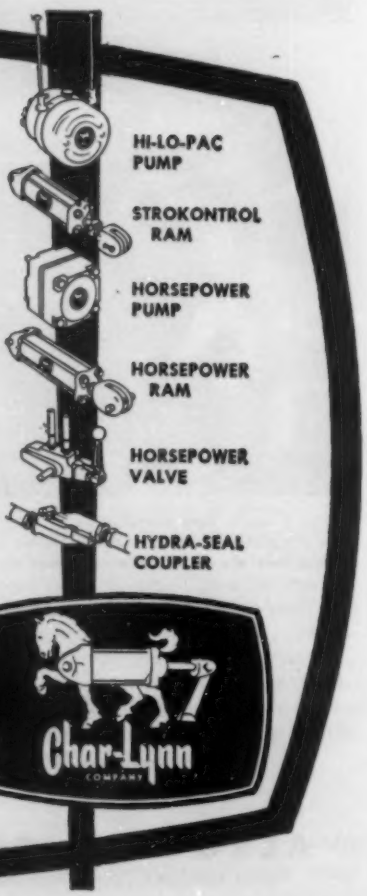
NEW

Char-Lynn HOLDKONTROL VALVE



MATERIAL: Die Cast Aluminum alloy body. Hardened steel valve spool.
CAPACITY: To 12 gpm. Built-in pressure relief, factory set at 1000 psi.
OIL PORTS: ⅜" NPF inlet and return. ½" NPF cylinder ports.
MOUNTING: 3 points with ¼" bolts. Any position for operator's convenience. Reversible mounting foot. 360° handle positioning.
SYSTEMS: Convertible to control single or double acting systems.
FEATURE: **HOLDKONTROL** returns valve to neutral position when cylinder reaches end of stroke. Adjustment eliminates **HOLDKONTROL** if desired. Spring return to center. ¼" lands seal cylinder ports in center position.
WEIGHT: Five pounds shipping weight.



The Char-Lynn Holdkontrol Valve is a general purpose valve for agricultural and industrial applications. It offers a combination of many features—all of which have never before been offered in a single valve. Built-in **HOLDKONTROL.** This frees the operator from holding the valve in an operating position. The valve can be returned manually to neutral, or it will return by itself when the pressure exceeds the relief valve setting. Modern industrial design . . . Envelope completely encloses and protects functional parts. Built to withstand surge pressures above 5000 psi.

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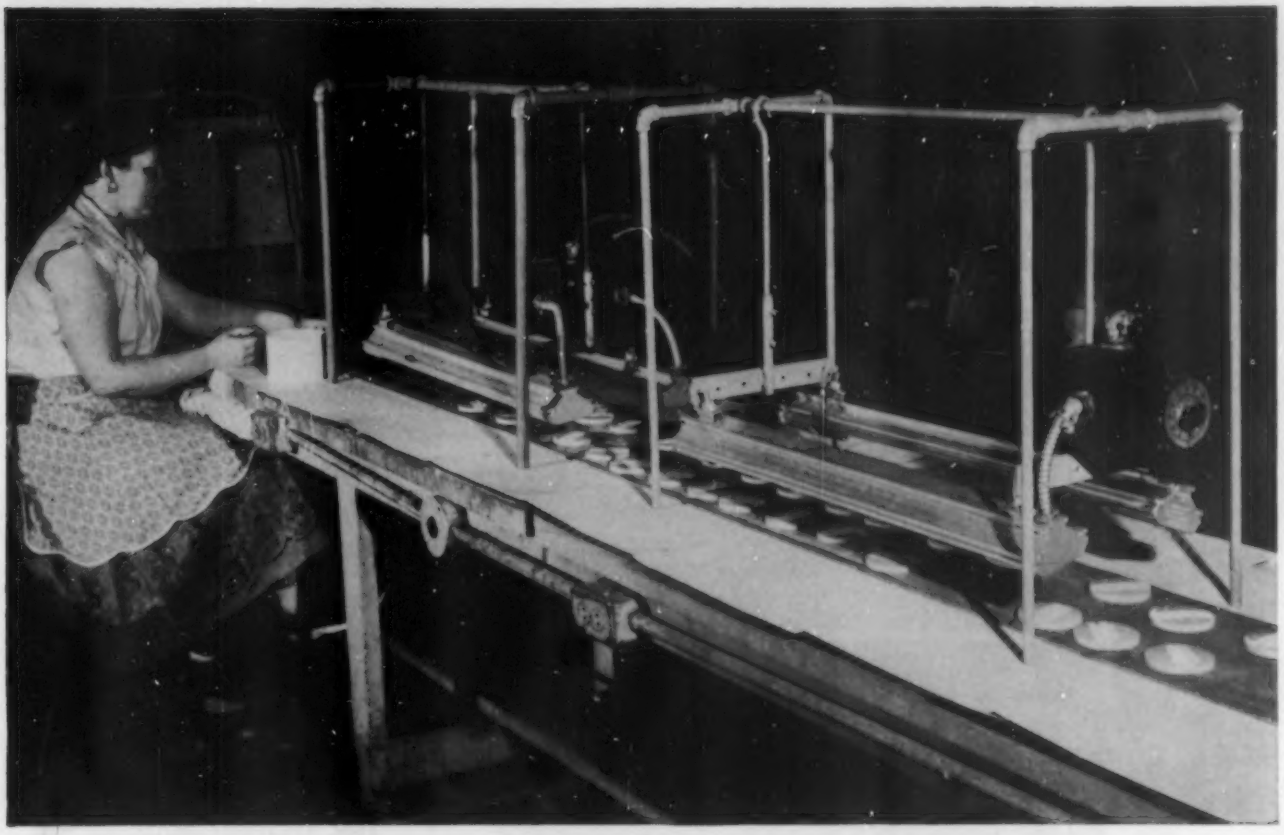

far-infrared heat . . . precisely controlled . . . solves problem of baking paint on plastic

Baking painted designs and lettering on plastic compact cases presented a tough production problem for this company. Too much heat blistered or melted the thermally sensitive plastic material. Too little heat wouldn't bake the paint properly. Added complications were the various bright colors involved.

Four "color blind" Chromalox far-infrared radiant heaters, having a total installed capacity of 7200 watts, provided the answer. The heaters are mounted lengthwise in pairs over the conveyor belt. The long wave length far-infrared radiation heats all colors with practically equal speed . . . and with negligible reflection even from white surfaces. Input controllers for each pair measure out the exact degree of heat required.

Results are rapid, uniform baking of the paint, regardless of the color. Stepped up production without damage to paint or plastic. Low initial investment, low operating and low maintenance costs of the lightweight, portable, all-metal Chromalox radiant heaters.

This problem-solution-result approach has enabled us to help many manufacturers produce better, faster, at lower cost.

Always available to you are our research, engineering, design and modern manufacturing facilities. The world's largest factory stock of industrial electric heaters plus local stocks at strategic points. And a 33-city nationwide sales-engineering service.

Let us know your problem for controlled heat and we'll go all out to help you find the right answer—electrically.

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check CHROMALOX electric heat for your application

Send for your copy of F1550—
"101 Ways to apply Electric Heat."

STOW flexible shafting ON THE JOB

pumping GAS on a tractor-trailer

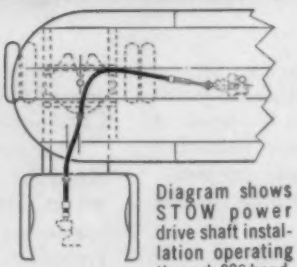

Diagram shows STOW power drive shaft installation operating through 90° bend.

STOW Flexible Shafts have effectively solved power take-off problems on both trucks and tractor-trailers. Large shafts, such as the 1¼" pictured above which transmits up to 10 H.P., have proven their ability on power take-off applications more efficiently and with more trouble-free service... **to operate pumps** for petroleum, milk and other liquids; **to operate conveyors** for grain, coal; **to operate compressors** on refrigeration trucks.

Why not put Stow to work on your power drive problems? Stow Engineers are always at your service.

For complete engineering data and illustrations on STOW Flexible Shafting—Write today for FREE Bulletin 525.

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STOW MANUFACTURING CO.

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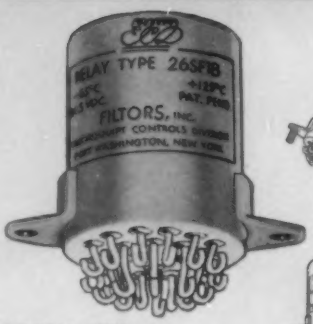
FILTORS, INC. SUB-MINIATURE RELAYS



ACTUAL SIZE

STYLE "SA"

STYLE "SB"

The Smallest 6PDT Subminiature Relay Available Today

STYLE "SE"

Mounting Styles To Meet All Your Requirements

STYLE "SC"

Filtors, Inc. is a major supplier of subminiature 6-pole and 4-pole relays. Our facilities are now utilized 100% for the development and production of relays of the highest quality.

STYLE "SR"

Outstanding Features

1. COMPACT
2. RUGGED
3. LIGHTWEIGHT
4. ROTARY MOTOR
   Precision built, with hydrogen annealed parts.
5. LONG LIFE

STYLE "SJ"

Also available in LATCHING construction, electrical reset, in contact arrangements up to and including 4PDT. This relay is the same as shown above, except for the number of terminals and the height of the enclosure, which is ¼" greater.

Meets or exceeds requirements of MIL-R-5757B.

STYLE "SL"

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Please send us your NEW CATALOG on Subminiature Relays.

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These typical properties show why Crucible 430 stainless was a good choice for the Murray worm drive clamp.

Tensile Strength — a. Room Temperature — 75,000 psi. b. At 1700F — 3500 psi

Yield Strength — 40,000 psi

Elongation — 30%

Hardness — 160 BHN

Endurance Limit — 40,000 psi

Creep Strength — Stress for 1% elongation in 10,000 hours at 1300F-1300 psi

Resistance to Scaling — Suitable for continuous service to 1600F.

the finest products wear a STAINLESS *label...*

When you label a product *stainless steel* it means lasting dependability . . . good looks . . . and resistance to wear or corrosion.

That's why the Murray Corporation, Towson, Maryland, chose Crucible stainless for the worm drive hose clamps shown above. These clamps need the high strength, wear and corrosion resistance that only *stainless steel* can provide.

Stainless has other advantages, too. Its high creep and fatigue strength . . . heat resistance . . . and excellent workability may be just what you're looking for.

At Crucible stainless steels are *prescription-made* by steelmen with over a half century of experience in *special purpose* steelmaking. They'll welcome the opportunity to help you make the most profitable use of stainless for your products. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

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ELECTRIC

Wheels Engineered for the Job

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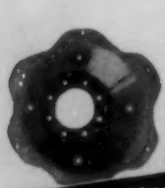


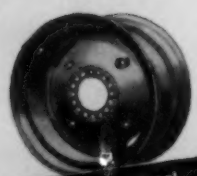
Rear Tractor Wheel for Demountable Rim

Planter Press Wheel—one piece rim with or without rubber tire

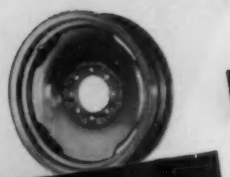
Rear Tractor Wheel Reversible

Pick-up Wheel Crown-face Steel Rim

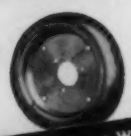
Garden Tractor Wheel Reversible



Combine Wheel Reversible



Spreader Wheel



Press and Gage Wheel Rubber Tire

SAE Implement Wheel Reversible

ELECTRIC WHEEL COMPANY

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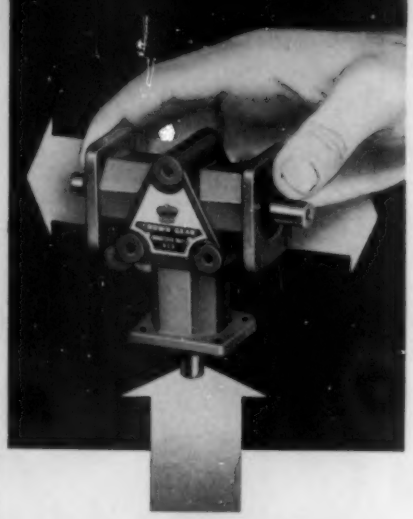
TRANSFERS POWER at RIGHT ANGLES



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Crown Gear Units have matched "Zerol" hardened gears which are mounted in double shielded ball bearings, and completely enclosed. Re-lubrication, if necessary, is easily accomplished, and four or five mounting flanges provide easy installation.

Special models will be engineered and quotations submitted for any specific problems. Write today for the name of your local distributor. Crown Gear Units are available almost everywhere.

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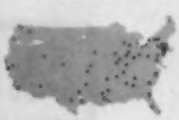
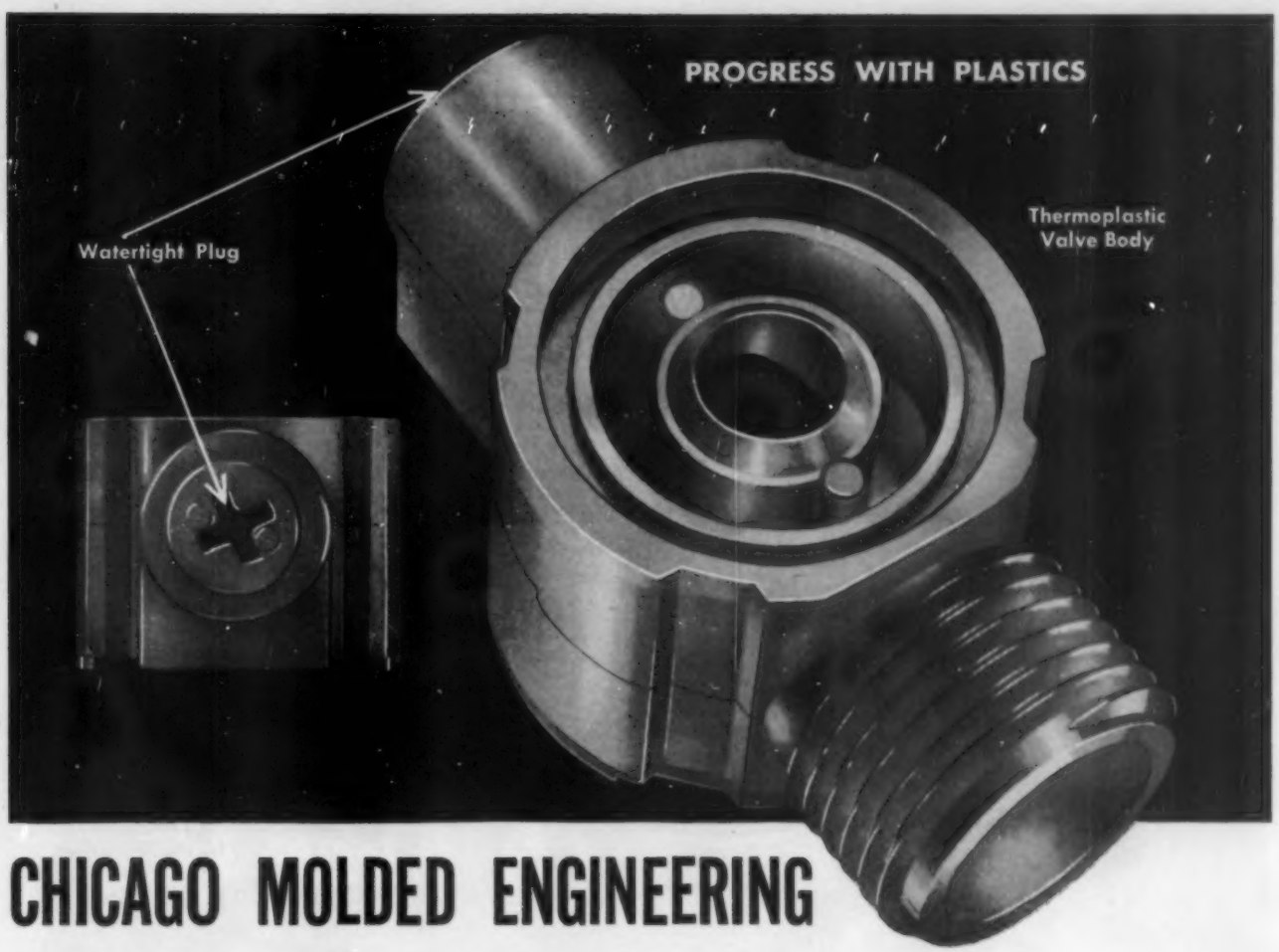


Over 120 leading distributors in 43 states, Crown Mitre Gear Units *are where you want them . . . when you want them.*

Sold in Canada by H. R. Arms Ltd. Montreal 23, P. Q.



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brings big economies to Dole Valve

PROBLEM — To secure a watertight seal between an intricate nylon valve body and a nylon plug. Formerly the plug was screwed into the body and an adhesive applied. This method proved slow, costly and ineffective.

SOLUTION — Chicago Molded suggested an entirely new fastening method for thermoplastics. The plug was tapered, instead of threaded, and then *fused into place* by a new CMPC welding process.

RESULT — A watertight seal very quickly made . . . top quality at a far lower cost.

In its first year, this process has meant a substantial saving for Dole. And it may be equally important to you – for it points up the kind of *creative engineering help* you get when you bring your molding jobs to Chicago Molded. By the way, a request on your letterhead will bring you more factual information on this money-saving engineering development.

• • •

Of course, we don't always develop a whole new process to solve your problems. But we do make it part of our everyday business to help simplify your problems with suggestions that improve quality, cut costs, or both.

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FLOWER

BRUSH HOLDERS

TANDEM
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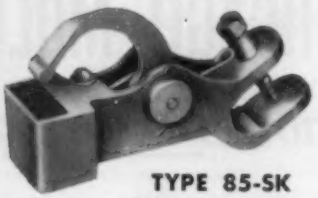

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for stationary motors and generators

There's a reason for the claim: "maximum motor and generator performance" – long life for both Brush Holders and Brushes is built into the units with highest quality bronze castings, precision machining – proper designing.

Known throughout industry for their enduring qualities, some of these units have lasted more than 24 years, under critical operating conditions. High resistance to vibration and wear assures you, your FLOWER BRUSH HOLDER will not cause breakdowns in production.

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FEATURES YOU WILL LIKE:

- Greater power from a more compact design.
- Resistance to corrosion throughout.
- Positive sealing with minimum friction loss.
- Materials selected for strength, durability and long cylinder life.
- Interchangeable heads and mountings.
- Conformation to J.I.C. Standards.
- Automatic compensation for rod packing wear.
- Built-in piston rod scraper to prevent dirt and abrasives from scoring rod or damaging packings.
- Adjustable cushions of unique design.
- Wide choice of operating pressures; Air to 250 psi; hydraulic to 750 psi.

The New HANNA T 750 Series *Fluid Power* CYLINDERS

● You'll find some unique and very interesting operating features in these new Hanna **T750** Series Fluid Power Cylinders . . . features that will help you solve many of your cylinder application problems more easily and more simply. The new Hanna **T750** Series comes in a range of capacities, sizes and mounting styles—for air operation up to 250 psi and hydraulic operation up to 750 psi.

For details, ask your Hanna Representative (see your classified telephone directory), or write today for a copy of the new **T750** Fluid Power Cylinder Catalog. No obligation.

NEW CATALOG

Write for Catalog 750A—it gives complete details.

Hanna Engineering Works

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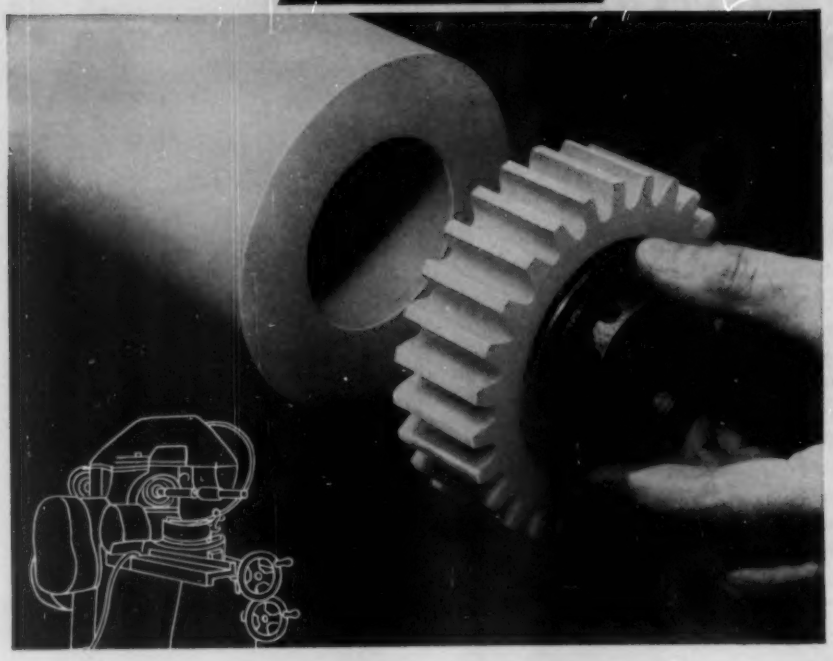
POLYPENCO® NYLON SHAPES



NOW! Get Nylon's Performance in Gears, Bearings . . . at Lower Cost

• POLYPENCO tubular bars now enable you to get nylon's advantages in gears, sleeve bearings, bushings, packings, and other large parts with big cost savings. Machining practically eliminates tooling cost, and this thick-walled stock assures minimum waste of nylon. Further savings can be obtained in nylon gears and rollers by making the outer sections from this stock and then combining them on metal inserts. POLYPENCO tubular bars are now available in 2" to 10" O.D.'s with ⅜" to 1½" walls. With this and other POLYPENCO shapes, you always get these advantages:

- Economical fabrication of one part or thousands on standard metalworking tools in your own shop
- Design flexibility . . . closer tolerances in many kinds of parts
- Uniform high quality in every piece
- Immediate delivery of most standard sizes
- Technical help

Write for new bulletin on nylon shapes.

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POLYPENCO® NYLON
... teflon* and other non-metallics

Warehouse stocks: Reading • Chicago • Los Angeles • Newton (Mass.) • Branford (Conn.)

*Trademark for DuPont tetrafluoroethylene resin

It's the new ADVANCE SQ—a telephone type that hits a new high in ruggedness and efficiency!

Only 15 milliwatts per pole will operate the new SQ relay in the DPDT combination. Here is sensitivity teamed with stable performance—the DPDT unit withstands 10 G's vibration from 10 to 500 cycles. When power is increased to 40 milliwatts per pole, vibration resistance rises to 30 G's. A single-coil relay, the ADVANCE SQ is available in 1- to 5-amp contact ratings, and in contact combinations from SPST to 6PDT. It comes through Signal Corps tumbling and shock tests in excess of 200 G's with operating characteristics unimpaired.

Sustained efficiency keynotes SQ operation. The use of a beryllium copper armature retaining spring insures positive contact between armature and pivot points at all times. Cross-bar palladium contacts are always properly aligned. A wide variety of coil resistances is feasible. Instead of organic insulation, the unit employs Silicone glass, Kel-F, or Teflon tubing. Life expectancy for 5-amp, non-inductive loads is 150,000 cycles... for 1-amp, non-inductive load: 1,000,000 cycles.

Open type dimensions are 1" x ¾" x 1⅜". DPDT units are supplied in a sealed container measuring 1" x 1" x 2". Write for literature on the SQ series.

ADVANCE RELAYS

ADVANCE ELECTRIC AND RELAY CO.
2435-C NORTH NAOMI ST.
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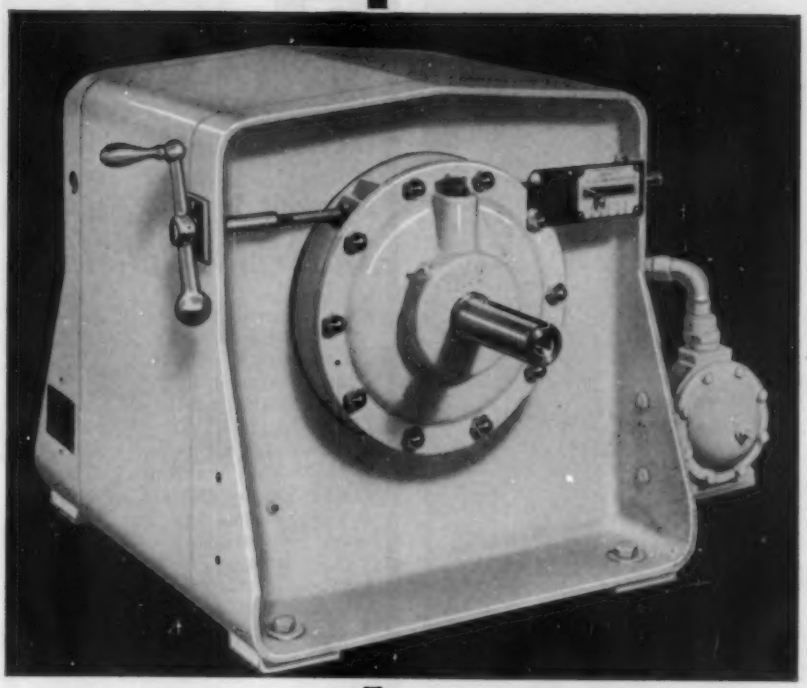
Sales Representatives in Principal Cities of U.S. and Canada

American Blower
Gýrol Fluid Drives
offer you

Adjustable speed over a 5 to 1 speed range



Think of the power and maintenance savings you'd gain from your equipment if you could eliminate special motors and expensive starting controls, yet still have an adjustable speed drive with a wide speed range.

You get this advantage with American Blower Gýrol Fluid Drives — plus the additional benefits of no-load starting, shock absorption, automatic or manual acceleration control and quiet operation.

The standard Gýrol Fluid Drive line includes constant-speed and adjustable-speed units — from fractional horsepower to 12,000 hp and speeds to 3600 rpm. Your nearest American Blower Branch Office has full information. Why not give them a call.

Typical Applications

PUMPS, AGITATORS, MIXERS
CONVEYORS, CABLE & ROPE MACH'Y
FANS AND BLOWERS
CENTRIFUGAL COMPRESSORS
PAPER AND PRINTING MACH'Y
TEXTILE MACH'Y

Principle of operation of Gýrol Fluid Drives

Runner Vortex of Oil Impeller

Operates on hydro-kinetic principle, using vortex of oil to transmit power from driving to driven machinery. Power is transmitted smoothly, evenly, efficiently without shock. Fluid Drive provides a simplicity of design and a flexibility of operation no other method of power transmission offers — plus an inherent safety factor.

American Blower products serve industry

- AIR CONDITIONING, HEATING, VENTILATING EQUIPMENT
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- CENTRIFUGAL COMPRESSORS
- GÝROL FLUID DRIVES
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AMERICAN BLOWER CORPORATION, DETROIT 32, MICHIGAN
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—wherever temperature limit indication is required

CPI PLUGSTATS provide precise thermal warning without calibration drift. Small physical size has been combined with rugged construction. Special alloy contacts assure clean make-and-break. Capable of 200°F overshoot from high or low normal setting. Available also with AN connector. Rated at ¼ ampere, 28 volts, AC or DC resistive loads. Contacts NO or NC. Weight approx. 1.5 oz.

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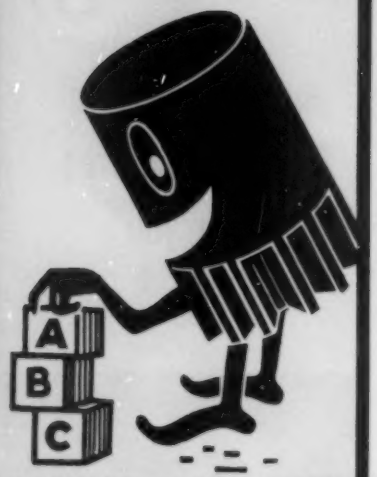

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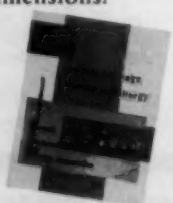

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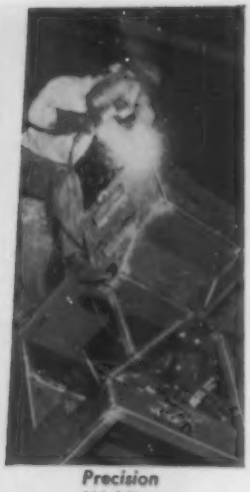

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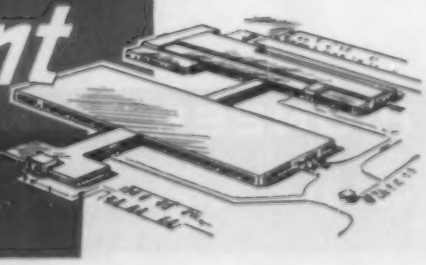

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ROLLWAY
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For Coolants,
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0 to 174 gpm

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Rugged dependability and factory-tested performance are only a part of the story behind Pioneer and Rollway pumps.

For 23 years Pioneer has specialized in the design and manufacture of impeller and positive displacement type pumps. This experience led to the development of a complete pump line of over 400 models. The model shown above is one of a complete line of flange-mounted and submergible type pumps which provides strict conformity to J. I. C. standards.

Pioneer pumps offer manufacturers many important advantages, such as the savings effected through the selection of standard pumps to meet custom requirements. Another important consideration in selecting Pioneer pumps is the unusual opportunity for standardization and interchangeability.

Pioneer application engineers will welcome the opportunity to discuss your pump requirements with you.

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Complete... Easy to Install... Reads from 0-1000; Accuracy ±0.1%. A complete system kit for obtaining digital information from standard self-balancing potentiometers. Easy to install, complete with all necessary hardware, this conversion does not affect the accuracy of the recording instrument, and no modification of the potentiometer is required. Readings can be taken while the recording pen is moving.

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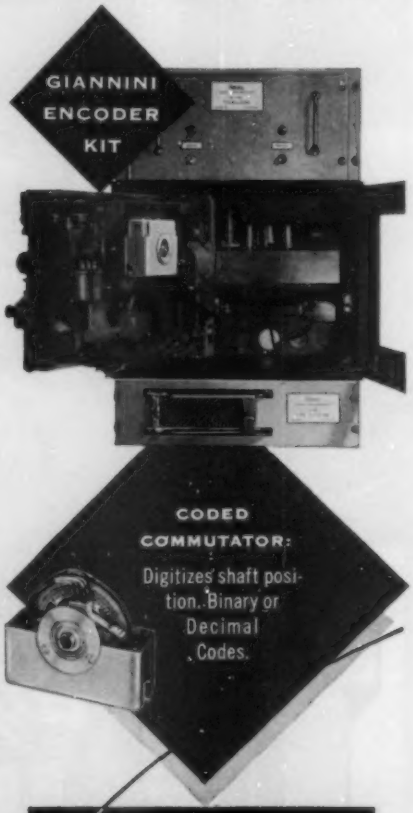

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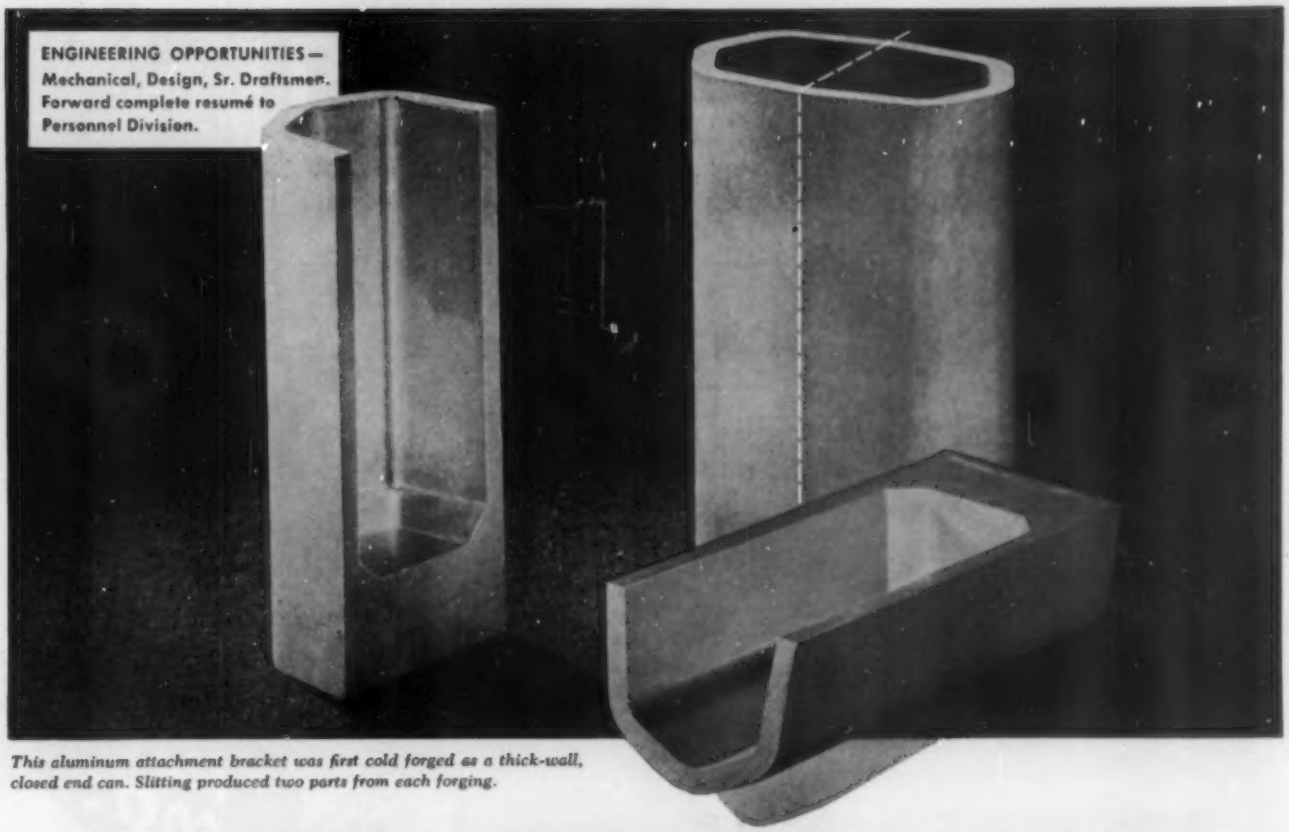


This aluminum attachment bracket was first cold forged as a thick-wall, closed end can. Slitting produced two parts from each forging.

HOW TO DESIGN HOLLOW SHAPES IN ALUMINUM

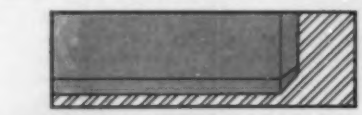
For Greater Production Economy

A typical example of how Hunter Douglas Aluminum Cold Forgings solve every-day design problems

Throughout industry there is wide use for can-shaped parts—not only as thin-wall cylindrical containers *but in heavy-wall, thick bottom, hollow shapes of varying part geometry which serve a multitude of industrial requirements.* The part illustrated is typical. A series of these act as attachment brackets on an airplane supporting an external wing tip fuel pod.

Because of its special shape, and high strength requirements, three alternative methods of manufacturing are open to the designer.

MACHINING FROM THE SOLID—This part could be machined from bar stock or from an extrusion having correct external shape.

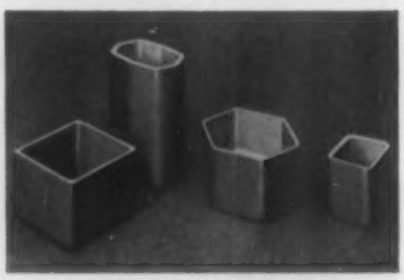


Shaded area indicates metal waste when machining from bar stock. Angled side walls in cavity combined with end detail complicate machining problems.

In either case, the cavity would have to be machined, with considerable difficulty experienced producing correct wall angle with a right-angled end. Both possibilities would be economically limited to relatively short runs.

HOT PRESS FORGING—Correct internal and external shapes can be obtained by hot forging, however, subsequent operations are essential. Draft on both inside and outside faces of the closed end must be removed, as well as any existing flash. Forging die costs are high and a trimming die is also required.

HUNTER DOUGLAS COLD FORGING—*Here is the ideal answer to production of hollow closed-bottom shapes.* By cold forging, both cavity and external geometry are instantly and simultaneously formed. Walls and ends are draft-free and uniformly thick over their respective areas. Being cold forged from a heat-treatable aluminum alloy, desired strength factors with extremely fine, dense, grain structure having continuous unbroken flow lines are obtained. Tooling cost for the cold forging is about half that of a press forging die.



These typical cans were all produced with heavy walls and thick bottoms; were subsequently split making two parts from each cold forging.

Actual cost comparisons between the three methods showed Hunter Douglas cold forgings 39% cheaper than machining from bar stock, 10% cheaper than press forgings.

Hunter Douglas Impact Forgings may hold new possibilities to lower costs and to improved design in your product. For maximum savings, get our engineering analysis *before investing in any other form of tooling!* A blueprint or sample part will suffice.

DESIGNERS:

If you want to know more about Hunter Douglas Aluminum Cold Forgings write on your company letterhead for this free 40 page book, now on the press!

Hunter Douglas Corporation

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Memo to Design Engineers

Only Stearns Magnetic Brakes Answer YES to These 20 Important Points

GENERAL

- ✓ Torque ratings range from 1 lb. ft. to 575 lb. ft. covering brake requirements on motors from 1/20 hp. to 100 hp.
- ✓ Visual indication of lining wear
- ✓ External adjustment for lining wear (when needed)
- ✓ Easy single-action torque adjustment
- ✓ External manual release
- ✓ Rugged construction
- ✓ Easy lining replacement
- ✓ Operate on motor mounted at any angle
- ✓ NEMA C mounting
- ✓ Floor mounting
- ✓ Stearns mounting (Standard for many motor manufacturers)

ENCLOSURES

- ✓ Standard through weather-proof
- ✓ Dust-tight, waterproof
- ✓ Underwriter's Laboratory-approved explosion-proof
- ✓ Marine service
- ✓ Navy service A (high impact)

ELECTRICAL

- ✓ Operate on any AC voltage, single, two or three phase
- ✓ DC shunt or series windings
- ✓ Maximum electrical safety factor
- ✓ Single coil in all sizes

1072

Stearns fast stop, instant release magnetic brakes are specified by the nation's leading motor manufacturers. For complete facts on Stearns Magnetic brakes and clutches, write for new detailed Bulletin 226-D.

MAGNETIC EQUIPMENT FOR ALL INDUSTRY

STEARNS MAGNETS

STEARNS MAGNETIC, INC. 631 S. 28th St., Milwaukee 46, Wisc.

Hassall

Established 1850

This cost:

SCREW MACHINE	$14.00 per thousand
COLD HEADED	$5.20 per thousand
SAVING	$8.80 per thousand

How about your fasteners or small parts? Have you had an estimate from HASSALL?

This is a typical example of how HASSALL saves thousands of dollars for cost-conscious manufacturers in hundreds of industries. This part is made in one piece by cold heading . . . the part is not only lower in cost but also stronger and just as accurate. Savings amount to $8.80 per thousand and this manufacturer used hundreds of thousands a year!

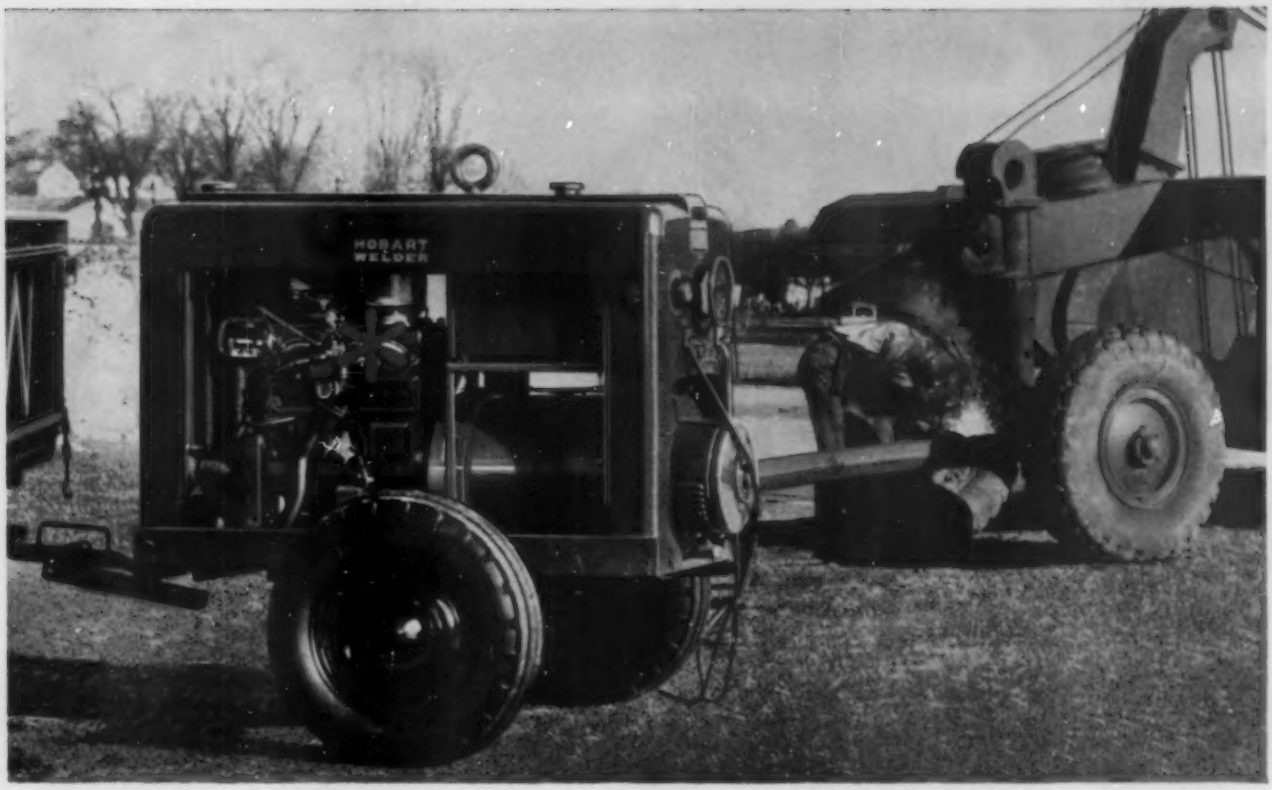
Perhaps your parts can be made by this better, lower cost method. Send samples or sketches of your parts for a prompt, $ $ $ saving quotation.

HASSALL SERVICE

- Send for 3 color decimal equivalent wall chart.
- On request, our 36-page catalog.

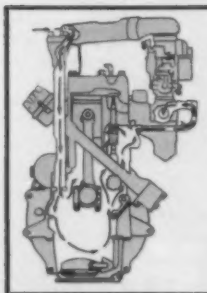
JOHN HASSALL, INC.

P. O. Box 2233 Westbury, Long Island, N. Y.



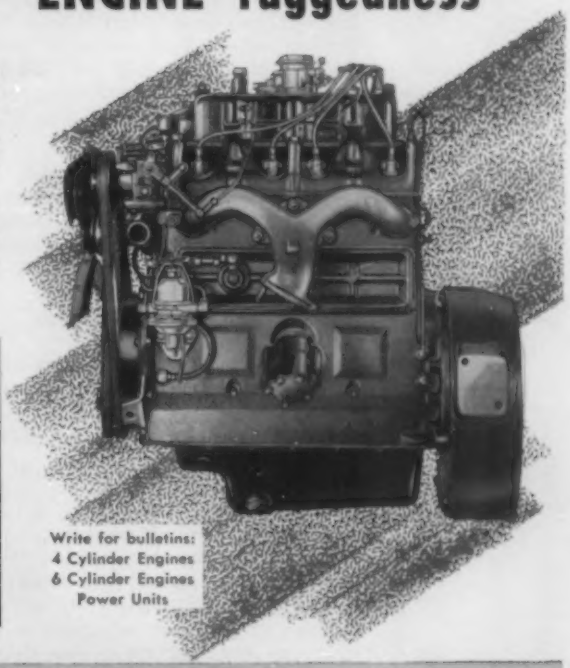
*Hobart Welder with JEEP ENGINE ruggedness

From the proven design of the perfected "Jeep" Engine has come four tough, 4 and 6 cylinder POWER GIANT Industrial Engines. Here's new low Engine maintenance . . . new high Engine dependability . . . whether installed directly into your equipment or employed in the Willys Power Unit. For technical information on Willys rugged designs and their "proven-in-action" features, write today.



POSITIVE
crankcase ventilation

Willys positive ventilation is **automatically regulated to engine speed.** Filtered air forces removal of oil-thining or acid-forming condensates. It is one of many Willys "proven-in-action" features for rugged power uses.



Write for bulletins:
4 Cylinder Engines
6 Cylinder Engines
Power Units

Willys

PROVEN IN ★ ACTION ★

POWER GIANT
Industrial Engines and Power Units

WILLYS MOTORS, INC. • *Industrial Engine Department*

1455 NORTH COVE BLVD. TOLEDO, OHIO

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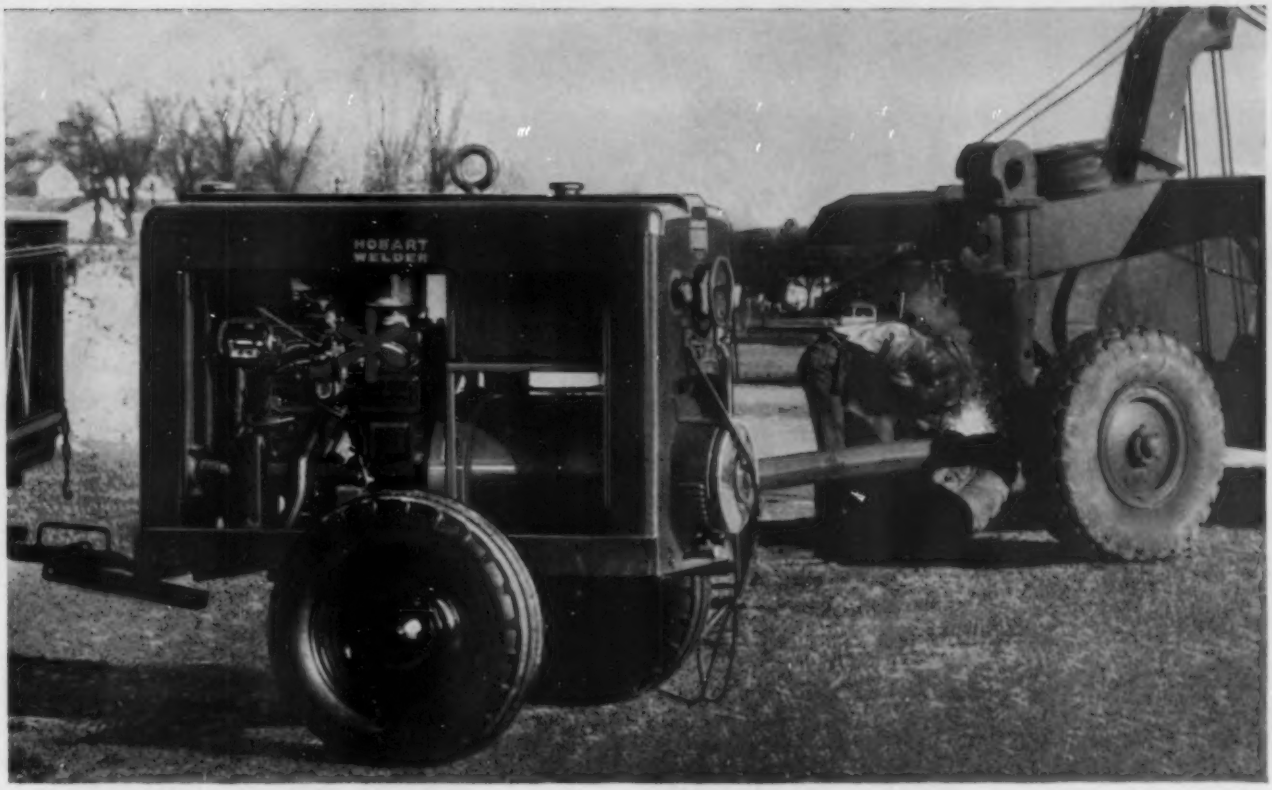

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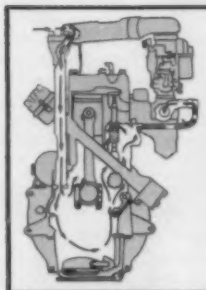

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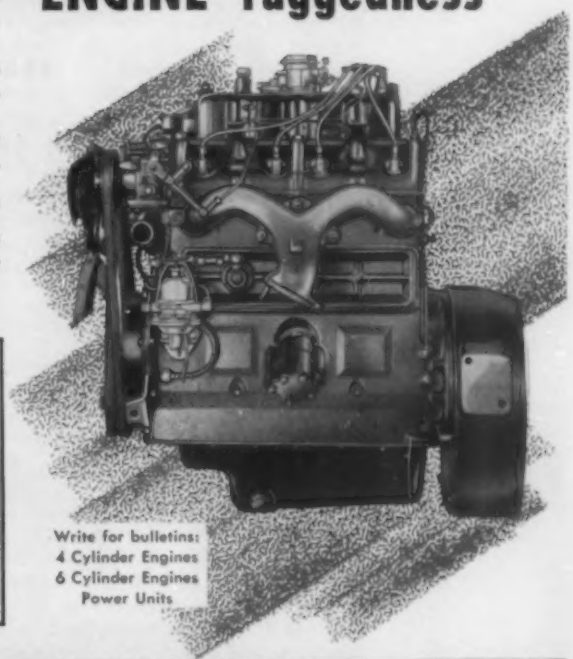

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POWER GIANT

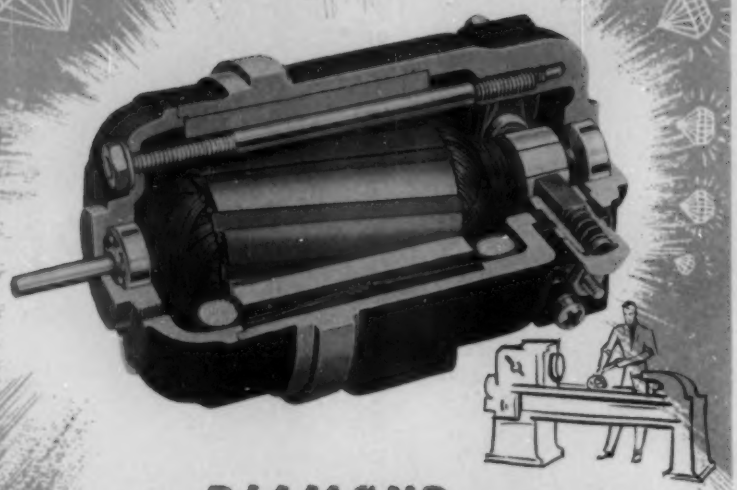
Industrial Engines and Power Units

PROVEN IN ACTION

WILLYS MOTORS, INC. • *Industrial Engine Department*

1455 NORTH COVE BLVD. TOLEDO, OHIO

as smooth
and precise



as a DIAMOND can make it
the ELINCO sub-fractional COMMUTATOR MOTOR

The precise, diamond finishing operation on the commutators of Elinco Motors is just one example of the exacting care that goes into every step in the design and manufacture of Elinco Commutator Motors. For years, Elinco has been an outstanding producer of instrument-type motors and generators, designed and built to meet exacting specifications. This specialized experience, plus highest standards of workmanship and quality, are your best assurance that Elinco can meet your precise requirements for sub-fractional hp commutator motors of every type.

ELINCO COMMUTATOR MOTOR FEATURES — For smooth, quiet operation, high electrical efficiency, long life, and dependable accuracy.

★ **Diamond turned and finished commutators**
★ **Bearing bores to 0.0001"**
★ **All components precisely sized and fitted**
★ **Close concentricity of bearings and laminations**
★ **Individual dynamic balancing**
★ **100% tested under all operating conditions**

GENERAL SPECIFICATIONS — With or without governor control. VOLTAGES — 6 to 230 volts. SPEEDS — 1,200 to 15,000 rpm. MOUNTINGS — by face, flange or base. FINISHES — to individual specifications. HORSEPOWER — 1/1000 to 1/6. TYPES — shunt, series, universal, permanent magnet, separately excited, etc. BEARINGS — double shielded ball, permanently lubricated. SPECIAL TREATMENTS — humidity, altitude, fungus, shock, vibration, high temperature, special materials.

Every Elinco motor is a precision instrument, manufactured to meet highest performance standards. Put our specialized design, engineering and manufacturing facilities at your disposal. Send us your specifications and let us select a motor to meet your requirements, or let us design and build one.

OTHER ELINCO PRECISION BUILT PRODUCTS
for instrument applications include:
AC Motors ★ Self-synchronous Units ★ AC and DC Tachometer Generators. ★ Non Standard Units for unique requirements.

Send for catalogs.

ELECTRIC INDICATOR COMPANY, INC.
108 Camp Avenue Springdale, Connecticut

ELINCO

INGENIOUS
PACKAGING

FOR ELECTROMECHANICAL DESIGNERS... IN THE DEVELOPMENT OF RADAR AND COMPUTING EQUIPMENT.

The most advanced developments in electronics are being made in the sphere of airborne radar and related ground control systems because of military emphasis. Further applications of electromechanical techniques in these fields are creating new openings in the Systems Division of Hughes Research and Development Laboratories.

Engineers who have demonstrated ingenuity and inventive ability will find interest in areas of work that call for devising reliable, maintainable, manufacturable designs for precision equipment developed at Hughes Research and Development Laboratories.

The design of this equipment, manufactured at Hughes, involves mechanical, electromechanical, electronic, microwave and computing problems. Design also requires the use of such advanced techniques as subminiaturization, unitized "plug-in" construction, with emphasis on design for volume production. Knowledge of electronic components, materials, finishes and military specifications is useful.

ENGINEERS
experienced in the field of electromechanical design at the research and development level, or those interested in entering this area, will find outlets for their abilities and imagination.

SCIENTIFIC AND
ENGINEERING STAFF

HUGHES
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HERE'S A WAY TO Cut Costs
LAMINUM® shims are easily and quickly adjustable. The laminations of brass, steel or aluminum are held together by a microscopic binder. They p-e-e-l for fast, accurate assembly. No counting of loose layers, no stacking, no miking. Less machining and finishing. Save in maintenance adjustments, too.
LAMISOL® shims, with layers tack-bonded at edges, are also available in brass, steel, stainless steel, aluminum.
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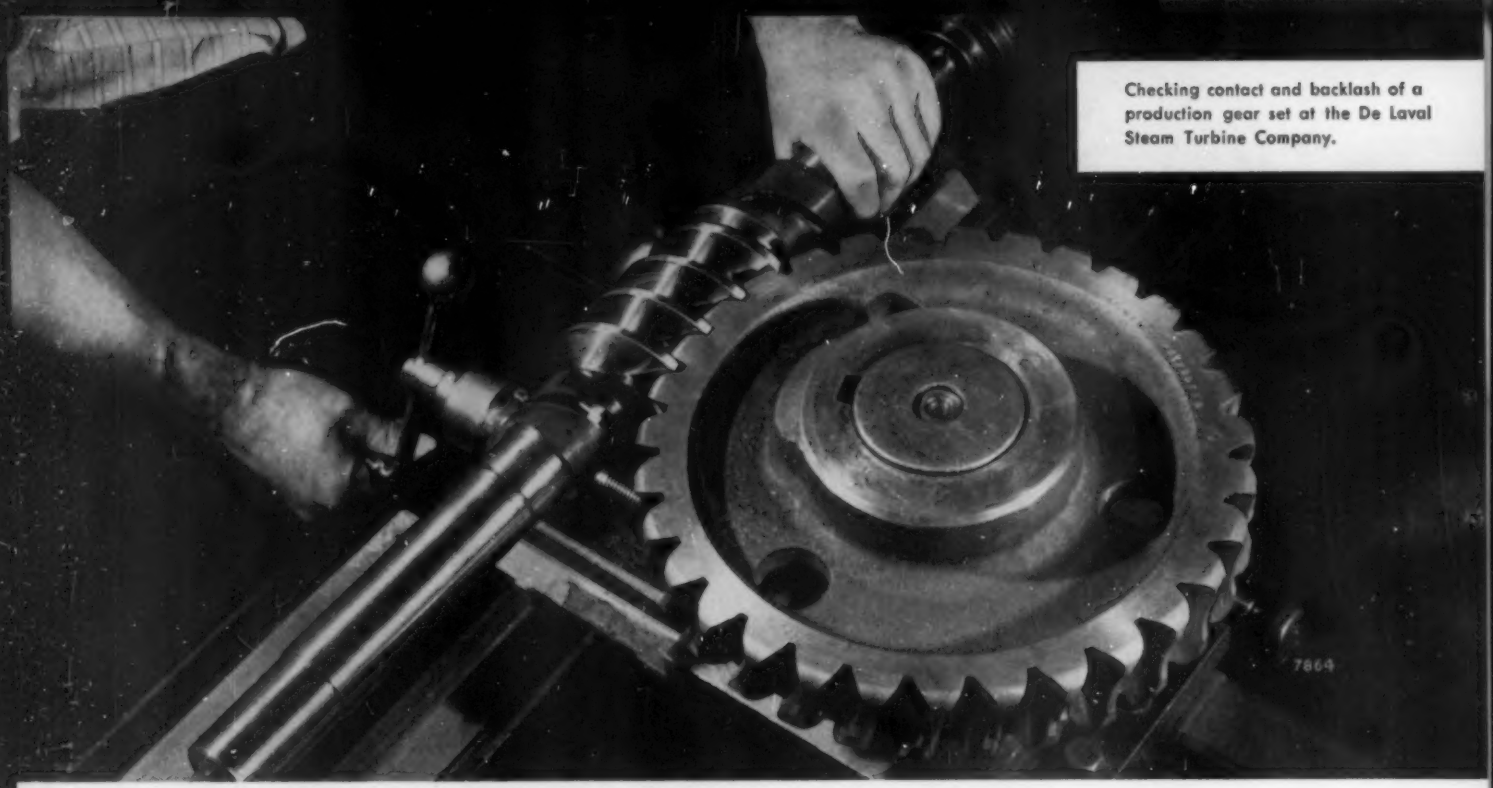
Send for FREE Brochure on how to save with Laminum Shims and Lamisol Shims



Checking contact and backlash of a production gear set at the De Laval Steam Turbine Company.

How to Save in Selecting Worm Gear Sets

By JAMES E. GUTZWILLER, *Assistant Chief Engineer, Worm Gearing Department*

De Laval Steam Turbine Company

Worm gear sets have four major advantages: compactness, easy maintenance, interchangeable components, and high shock-load capacity. The user can realize maximum benefits from these advantages and reduce costs by acquiring some background information on the characteristics of worm gearing. Here are a few points to consider.

Standard Components. Find out what standard components are available before proceeding with design. De Laval stock parts include worms, gears, bearing housings and end covers. By selecting from these, the user may sharply reduce the cost of the finished gear set.

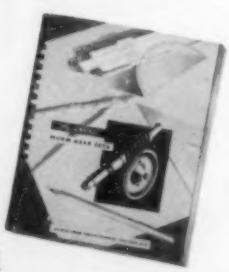
HOBBING MACHINE — Tangential feed gives uniform teeth of precise dimensions. This is accepted as the most satisfactory method for producing close tolerance worm gearing.

The hob, for example, must match the pitch diameter, pitch, lead and tooth form of the worm. Designers who are familiar with standard hobs can design a worm accordingly and save the expense and delay of obtaining a special hob.

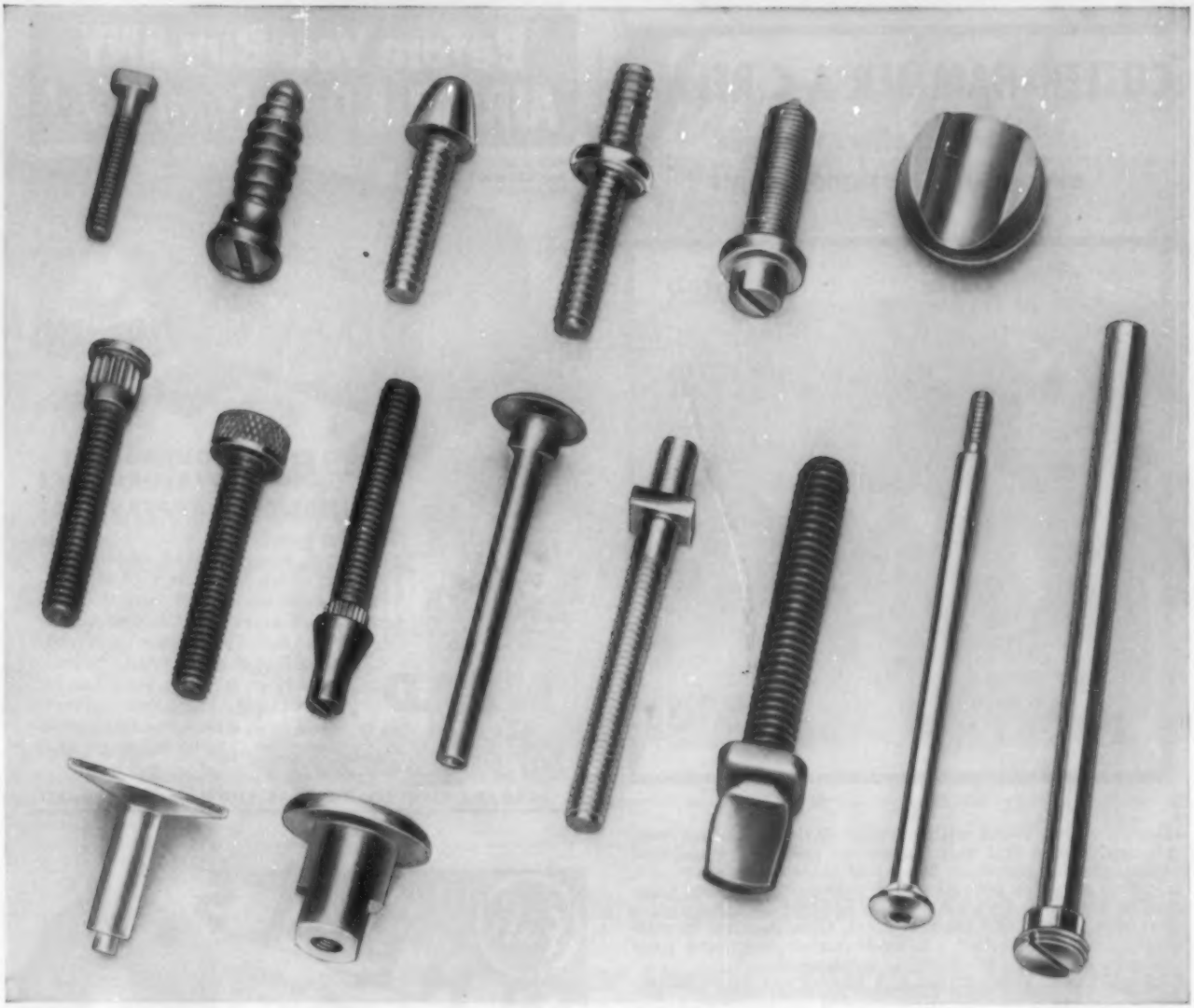
A Note on Assembly. The worm, having threads which are continuous in form, is not critical in regard to endwise location. The gear, however, must be precisely positioned in an axial position. Accumulation of tolerances on the dimensions of housings, shafts, bearings and gears makes it impractical, in most cases, to control the location of the gear by accuracy of machining alone.

Shrouding. Heat developed in the gearing will be more freely dissipated through a comparatively open housing. Close shrouding is permissible only when intermittent operation is the rule.

Helpful Manual on Worm Gear Sets



For information on how to select, install and maintain worm gear sets, send for this helpful manual. It contains useful data on gearing and includes examples of specific selection problems with their solutions. Write on your business letterhead to the De Laval Steam Turbine Company, 801 Nottingham Way, Trenton 2, N. J. for Catalog 5000.



This picture represents . . .
$140,000.00 saved for manufacturers by HARPER

By cold heading these parts, Harper has been able to save manufacturers over $140,000.00 from what they would cost if they were milled from bar.

For a third of a century Harper engineers have been devising new and better methods of cold heading. For nearly a third of a century, they have been solving problems having to do with the production of special parts in quantity at low expense by the cold heading method.

If you are today milling small parts, there is a good likelihood that The H. M. Harper Company can show you how you can save money—perhaps lots of money!

Harper specializes in fastenings of non-ferrous metals, stainless steels and high temperature alloys. If you require parts in any of these metals, standard or special, call on Harper.

Harper engineers are available to work with you on any special problem, and Harper Branch Offices and Distributors have warehouses containing thousands of standard bolts, nuts, screws, washers and rivets ready for delivery, to every market area.

THE H. M. HARPER COMPANY
8203 Lehigh Avenue, Morton Grove, Ill.

Specialists in <u>all</u> corrosion-resistant fastenings

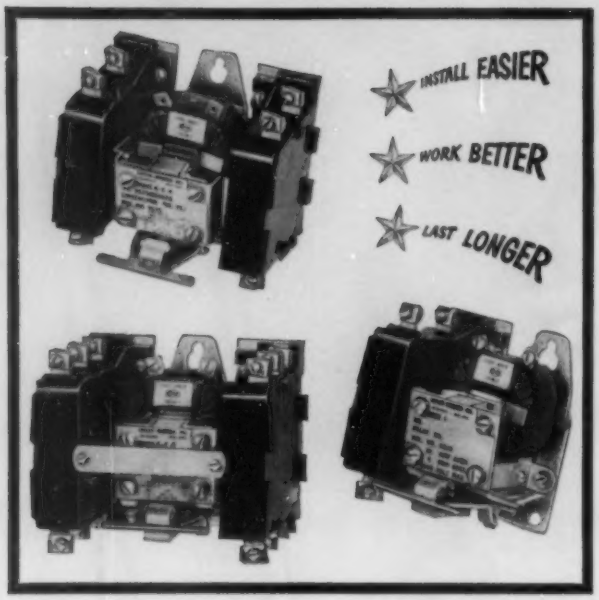
Bolts • Nuts • Screws • Rivets • Washers
of Brass • Bronze • Monel • Aluminum • Stainless

OVER 7000 ITEMS IN STOCK . . . HARPER DISTRIBUTORS EVERYWHERE

HARPER
EVERLASTING FASTENINGS

CUTLER-HAMMER A-C RELAYS

New design offers features every panel designer wants



Designers are faced with ever-increasing machine complexity. More and more functions are being combined within single machines. More and more motors are used. Control circuitry becomes more and more complex. Control relays, usually called upon to operate much more frequently than the main control, thus become increasingly important. And Cutler-Hammer engineers have met the challenge of changing requirements.

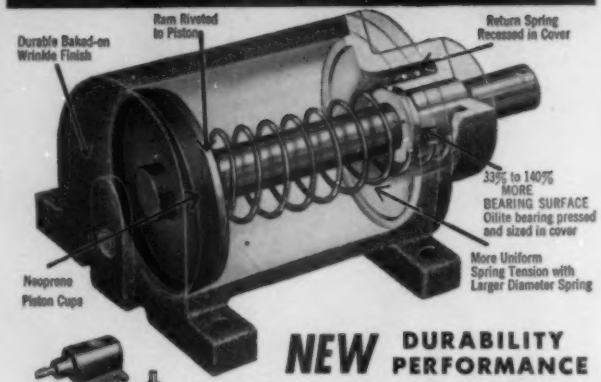
First, the new Cutler-Hammer Bulletin 9575 A-C Relays provide such greatly increased electrical and mechanical life that they will *never* require replacement in all normal uses. They have dust-safe vertical contacts now doubly improved. Low-inertia movable contact structures cut bounce, the principal cause of arcing which destroys contacts. And the contacts are enclosed in pressure-quenching arc chambers. Armatures move on pivot bearings, avoid the uncertainties of sliding friction, assure quiet, trouble-free operation.

Second, the new Cutler-Hammer Bulletin 9575 A-C Relays were designed for easiest installation, wiring, and accessibility for inspection. Three-point keyhole slot mounting. Self-retaining screws. Straight-through wiring. Pressure connectors on all terminals that can secure two wires of different sizes. Terminals arranged for unobstructed accessibility from front. Easily convertible NO-NC contacts, circuits identifiable without removing contact chamber covers. Clearly visible rating and data on nameplate. Instant coil identification. Contact block and magnets may be easily removed as units and may be quickly disassembled.

Cutler-Hammer 9575 A-C Relays are available in 2, 3, 4, and 6 poles, 10 and 15 amperes, 25, 50, and 60 cycles, 6 to 600 volts, in open type or in NEMA 1 enclosures. Carried in stock by many Cutler-Hammer Authorized Distributors. Phone or write for full information. CUTLER-HAMMER, Inc., 1332 St. Paul Avenue, Milwaukee 1, Wisconsin.

CUTLER-HAMMER
MOTOR CONTROL
C-H

Before You Buy ANY AIR CYLINDER-*Study this!*


Durable Baked-on Wrinkle Finish
Ram Riveted to Piston
Return Spring Recessed in Cover
33⅓ to 140% MORE BEARING SURFACE Oilite bearing pressed and sized in cover
More Uniform Spring Tension with Larger Diameter Spring
Neoprene Piston Cups

Some of the 26 newly perfected single-acting Air Clamps.

NEW DURABILITY PERFORMANCE SIMPLICITY • APPEARANCE

See the construction of this newly perfected single-acting Mead ®Air Clamp cylinder. Compare with others—you'll switch to Mead! Now all perfected single-acting Air Clamps use less air—to further cut your costs feeding, holding, ejecting, finished pieces. They are in stock at your nearest Mead Man for immediate delivery.

MEAD *Air-Clamp*® ®Air Cylinder

Write to Factory or Nearest Mead Representative for Bulletin No. PE-45

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F&H for MOBILITY at its BEST WHEELS

Meet your wheel problems with "WHEELS by French & Hecht." Our experience, facilities and "Know-How" are your assurance of matured and tested recommendations—as well as wheel-hub-spindle-bearing assemblies perfectly suited to your requirements. In ONE engineered package, we offer you—

- DESIGN of Wheels and HUBS
- DESIGN of SPINDLES and AXLES
- SELECTION of ADEQUATE BEARINGS
- SELECTION of Suitable Closure SEALS
- SELECTION of Sizes, Types, Rubber TIRES

INTEGRATED ENGINEERING — WHEEL BUILDERS FOR AGRICULTURE & INDUSTRY

We Invite Your Inquiries

OUR PACKAGE PLAN

Our PACKAGE PLAN can save you Research, Development and Tooling Costs.

FRENCH & HECHT
DIVISION
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DAVENPORT, IOWA

TAYLOR Laminated Plastics Vulcanized Fibre

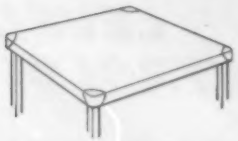
Shop Talk

TAYLOR FIBRE CO.

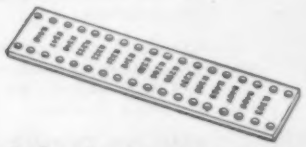
Plants in Norristown, Pa. and La Verne, Calif.

PHENOL—MELAMINE—SILICONE—EPOXY LAMINATES • COMBINATION LAMINATES • VULCANIZED FIBRE • POLYESTER GLASS ROD

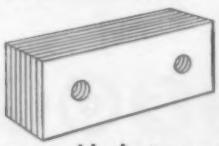
Tips for designers



Furniture can make good use of the mar-resistant, tough surface afforded by Taylor Vulcanized Fibre plywood combination table tops.



Terminal strips for high-precision electronic instruments benefit by the excellent insulating properties of Taylor XXXP-301 hot-punch phenol laminate.

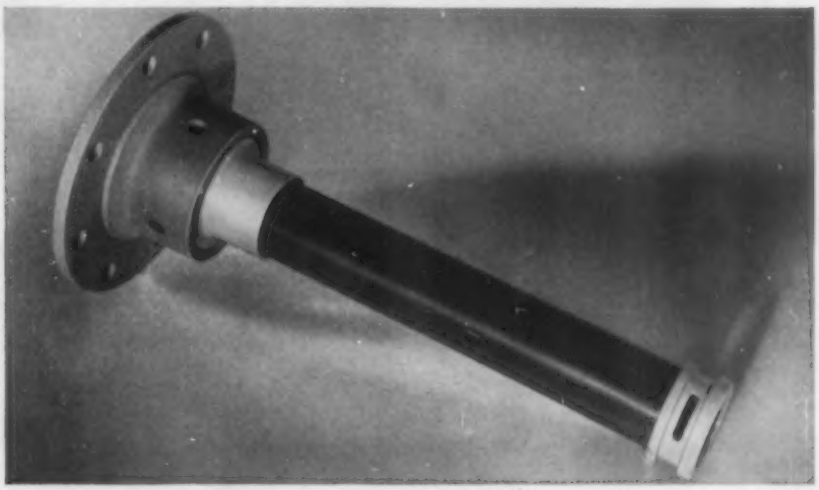


Heavy bumper blocks for steel mill use, made of Taylor Built-Up Fibre several inches thick, give long service under severe shock and abrasion.

Selenium rectifier plates are insulated by washers made of Taylor Grade 353 phenol laminate . . . chosen for its dimensional stability and mechanical strength.

TAYLOR FABRICATING FACILITIES

Your production can be simplified . . . schedules safeguarded . . . inventory headaches cured . . . and overall costs reduced by having Taylor fabricate finished parts to your specifications. Efficient, modern facilities are ready to serve you. Get in touch with Taylor about your specific requirements.



High strength, light weight, excellent insulating and corrosion-resistant qualities make Taylor Epoxy Glass Base Laminate the ideal material for tubing in an aircraft fuel gage tank unit made by Avien, Inc.

When service conditions are tough— *use Taylor special-purpose laminates*

Designing for severe service? Then take a look at what Taylor special-purpose laminates can do. Taylor's resin chemists have developed special formulations of melamine, silicone and epoxy resins . . . for combination with a variety of base materials. The result is a line of laminates which offer the plus performance that your new designs may require.

Taylor epoxy laminates. Retain superior mechanical properties after exposure to high temperatures (above 430 F) . . . have outstanding electrical characteristics, moisture resistance and resistance to corrosive chemicals . . . setting these laminates apart as a means of solving difficult design problems.

Taylor melamine laminates. Excellent resistance to arcing, electrical corona, flame and chemical attack characterizes these materials . . . useful in many electrical applications.

Taylor silicone laminates. These withstand temperatures up to 500 F . . . provide insulation where other laminates thus far cannot be used. They also possess high mechanical strength, low power factor and low moisture absorption.

Sheets, tubes and rods of these materials are available in a range of sizes that will give you maximum economy of material in your manufacturing processes.

To help you in the application of these specialized materials to your specific product, Taylor offers the service of its experienced engineering staff. Call on Taylor for a consultation on your individual requirements.

• NYLON GEARS

CAN SAVE YOU UP TO 90% ON GEAR COSTS . . . . .

• QUIET • DURABLE • EFFICIENT • NEED LESS LUBRICATION •

FOR over a decade we have been manufacturers of fine pitch gears. In this we are serving some of America's most particular users of precision and commercial gearing.

Now we have added a completely equipped department for producing Nylon Gears. Because of our past experience and our facilities, we are a logical source for Nylon Gears. We can mold large quantities at savings up to 90%. We can cut smaller quantities from molded blanks at definite savings. We can produce experimental work cut from Nylon bars.

A Nylon Gear can mate with a metal gear—we can make both—and be responsible for the performance of both. Benefit by our KNOW HOW to SHOW HOW Nylon Gears can be adapted to your use.

103

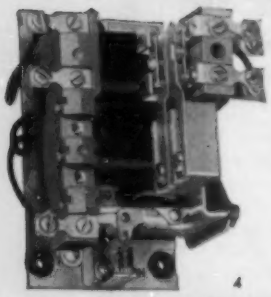
When you think of gears . . . in any material . . . think of GEAR MEN

P G

PROCESS GEAR CO., INC.

4602 WEST FULLERTON AVE. CHICAGO 39, ILLINOIS

All Electric FLOATLESS LIQUID LEVEL CONTROLS



The original—pioneered by B/W in 1933. No floats! No moving parts in liquid. Literature describes relays and starters, automatic starter and relay combinations, multiple pump controls, special controls and panels and many application diagrams.

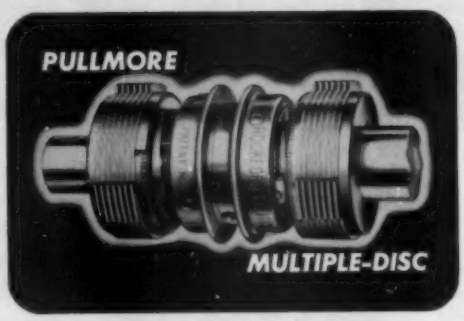
Controls not affected by pressures, temperatures, acids or caustics. Remote control if desired. Ice free electrodes where necessary.

WRITE FOR CATALOG

B/W CONTROLLER CORPORATION

2218 E. Maple Road, Birmingham, Mich.

ROCKFORD



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EASY ADJUSTMENT

• These compact, powerful, multiple-disc clutches are helping product engineers to reduce size and weight of the vital link between the driving and driven units of machine tools, lift trucks, overhead cranes and a wide variety of other production equipment. They readily fit into product designs, accommodating great torque capacity within small size. Precision grinding insures perfect fit on the clutch shaft. Symmetrical contours avoid drag that is caused by centrifugal force.

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Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD CLUTCH DIVISION BORG-WARNER

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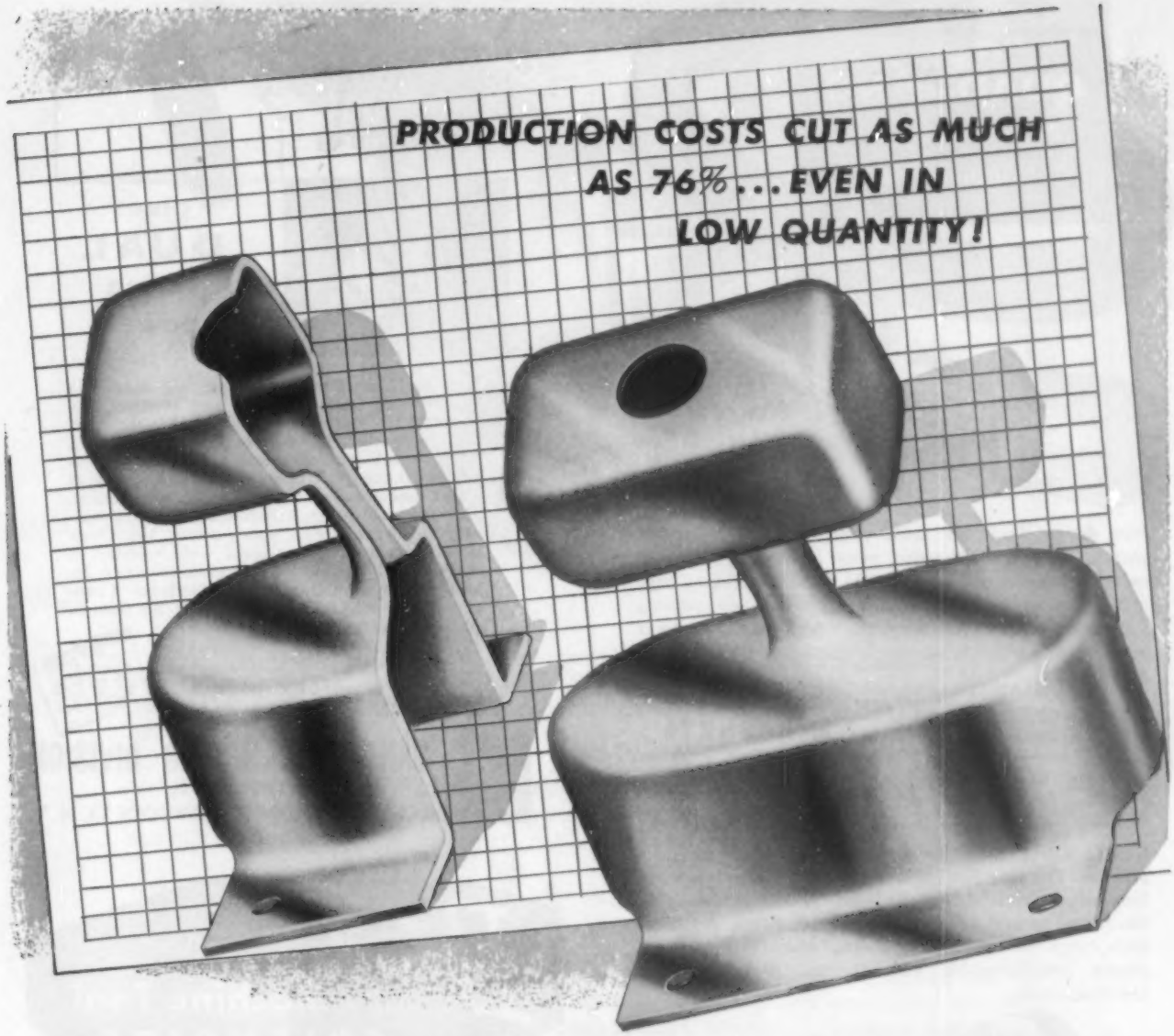
CLUTCHES



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Shapes impractical or expensive to obtain by conventional methods can now be produced economically by investment casting in magnesium as well as other metals. Arwood can cast, at substantial savings to you, complex parts in difficult-to-form alloys.

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CASE STUDY

METAL: Magnesium (QQ-M-55 Comp. AZ-92-A)

PARTS: Designed and cast as single unit.

QUALITY CONTROL: Chemical and Physical affidavits furnished. Test Bars submitted. Produced under X-ray control.

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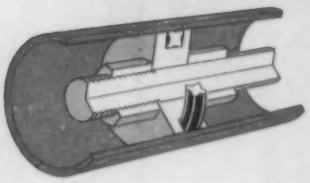

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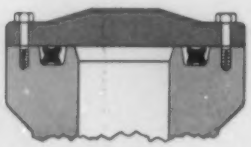
for reciprocating motion

New design eliminates "spiral twist," common cause for packing failure. Users report much less drag and breakaway in installations with QUAD RINGS. Leading edge acts as wiper ring to minimize abrasion and prolong service life. QUAD RINGS form a positive seal under a wide range of pressures—are particularly efficient at 0 to 5 psi.



2 GASKETS
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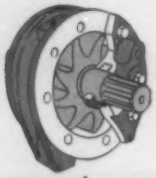
QUAD RING design prevents excessive distortion under pressure. The four lips prevent "by pass" in devices using frequent pressure cycles. Reduced "working action" in the groove permits rougher groove finish. Made in a complete range of sizes corresponding with O-rings. Completely interchangeable with O-rings, eliminating any conversion costs.



3 ROTARY SEALS
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Field reports show many successful and easily serviceable applications of QUAD RINGS on rotating devices. QUAD RINGS permit much higher rotation speed and longer service life through reduction of friction.

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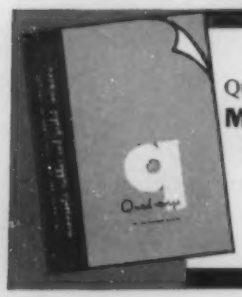

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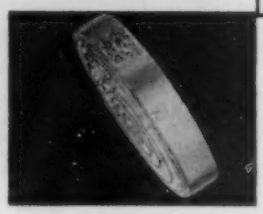
Crosscurving **in a spring**



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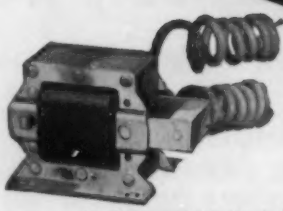

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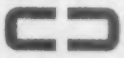
Valparaiso, Indiana, April, 1955 — The Indiana Steel Products Company, world's largest manufacturer of permanent magnets, has released information on the development of an important new product...a one-piece wound core.

Called the "Hyflux," its applications are the same as conventional C-type cores...distribution, welding, X-ray, lighting, and special transformers and saturable reactors.

The one-piece core consists of just one piece instead of two pieces  as in the conventional C-type cores.

Because the one-piece core has but one air gap, instead of two, there is definite improvement in performance...and exciting current is normally lower, often by a significant amount. Vacuum impregnating is not necessary (only the sides of one-piece cores are varnished) and resulting electrical losses are eliminated.

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Hyflux "one-piece" wound cores are now available in the more popular 12-mil standard core sizes. You are invited to write for descriptive literature to: The Indiana Steel

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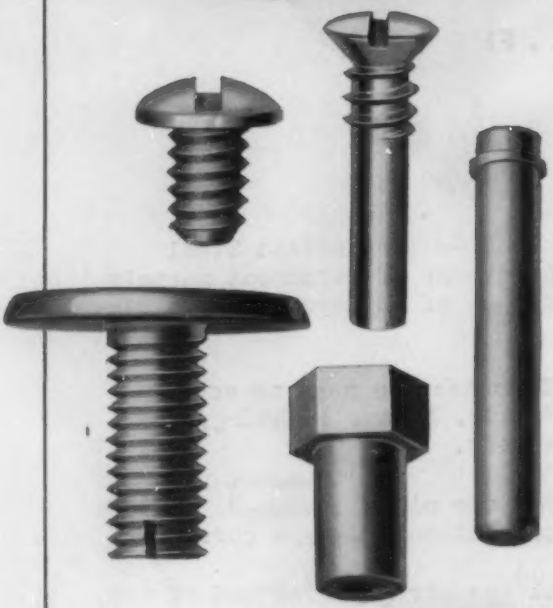
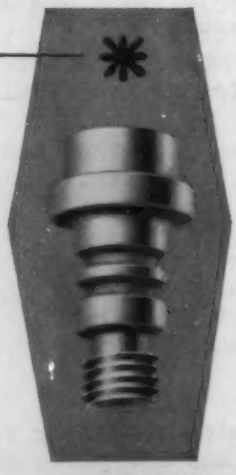


FOR EXAMPLE

This stainless steel part was formerly made by another method of manufacturing. By using the Cold Heading method to produce this part, a savings of $46.15 per thousand was realized by the customer.



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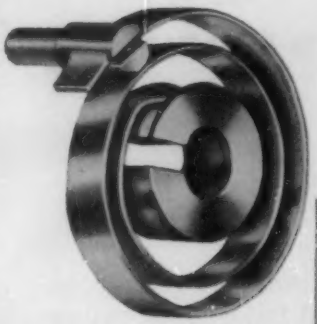

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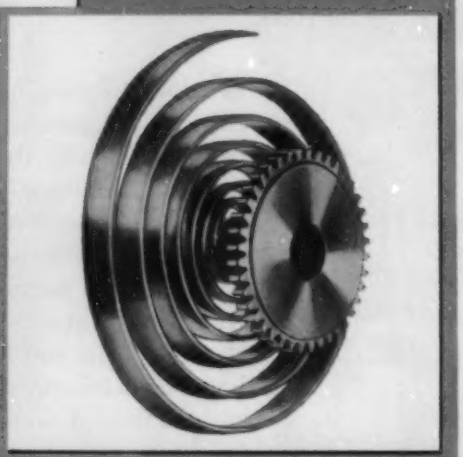

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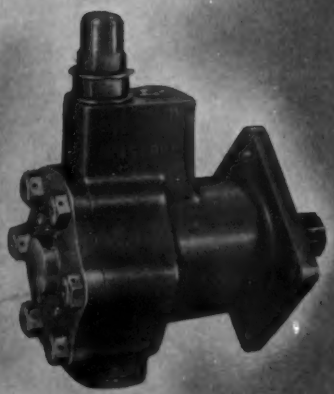

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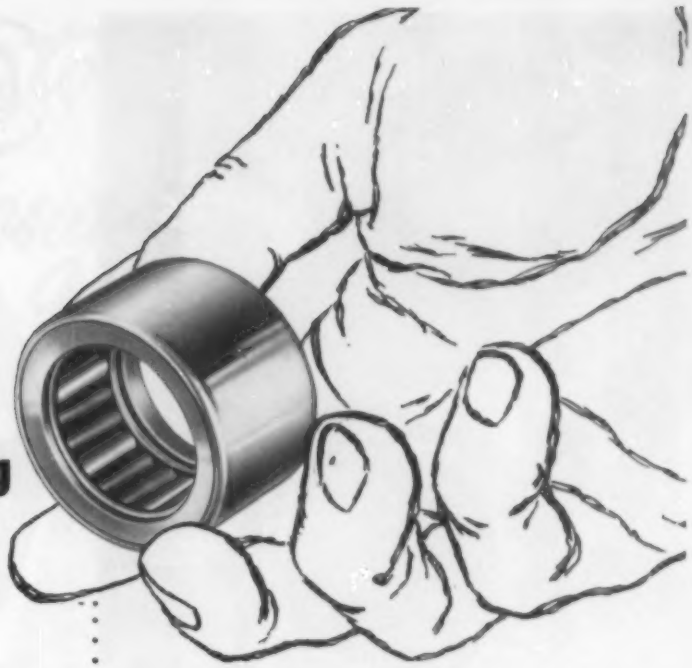

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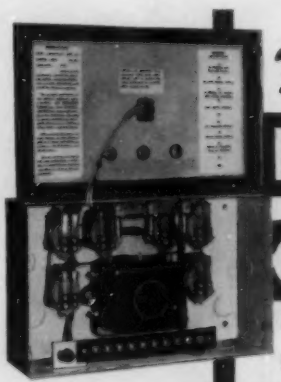

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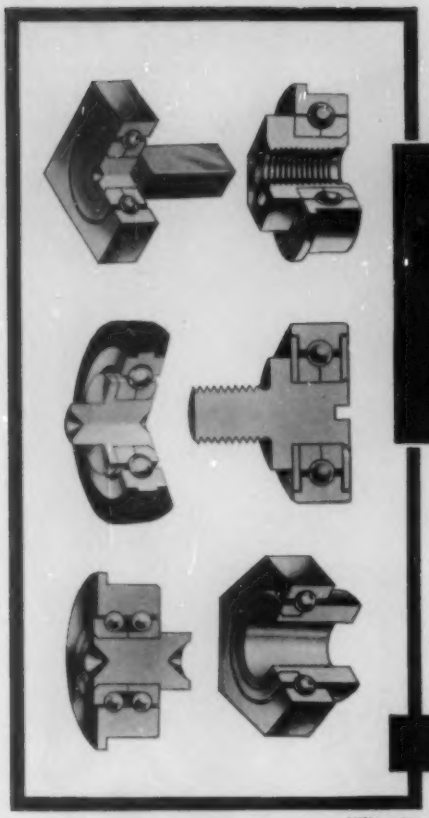

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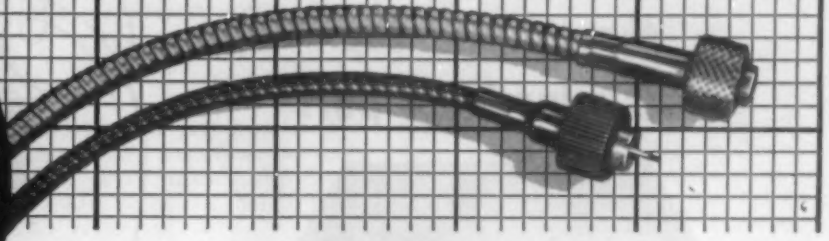
FLEXIBLE SHAFT

Fact and Fiction

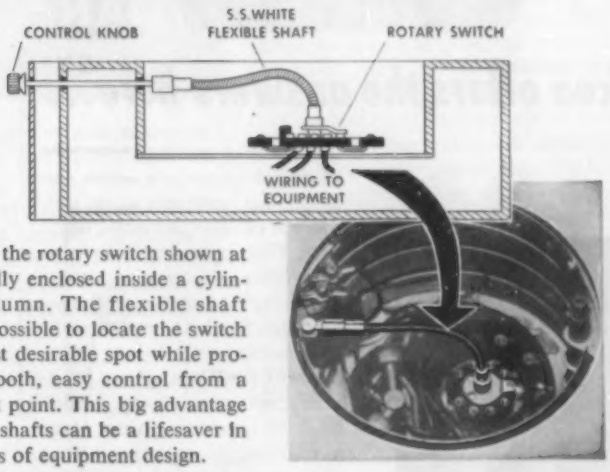


FACT

For mechanical operation of inaccessible parts, S.S.White flexible shafts will do the job better . . .

WHY? Because S.S.White flexible shafts provide a *single, self-contained, easily applied unit* for transmitting power to drive the inaccessible parts or for providing manual control to the parts. This means fewer parts, simplified assembly, no alignment problems, and lower costs. Also, in many cases, flexible shafts can save space because they give wide latitude in locating driven or controlled parts.

EXAMPLE — Remote control for a rotary switch



In service, the rotary switch shown at right is fully enclosed inside a cylindrical column. The flexible shaft makes it possible to locate the switch in the most desirable spot while providing smooth, easy control from a convenient point. This big advantage of flexible shafts can be a lifesaver in many cases of equipment design.

FLEXIBLE SHAFT FACTS FOR DESIGNERS

BULLETIN 5306 gives basic information and data about flexible shafts and tells how to select and apply them. Write for a free copy. Address Dept. D.

F-1

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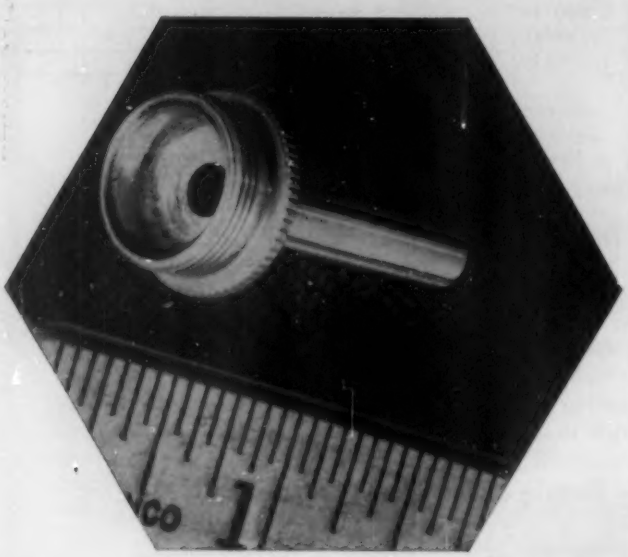
FICTION — Flexible Shafts Are All Alike

Actually, there's a big difference in flexible shafts — a difference which is reflected in the operation and performance of your product. S.S.White flexible shafts, which incorporate the latest technical and engineering advancements, give a positive assurance of superior service. And backing this up is a staff of experienced flexible shaft engineers who are ready to cooperate with you in working out the necessary details to insure the success of your application.

There is a right way to thread and tap this aluminum part



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FOR PRODUCT DESIGNERS

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Not exactly helpful to the motor that drives your mechanized buggy is rust in the radiator.

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As you can see from the picture, this handy-dandy item consists of a metal cone filter, neatly ensconced in a glass bulb. This diminutive defender fits between the radiator and the block, spliced, as it were, between a couple of lengths of hose.

The basic purpose is to keep rust from clogging the radiator. Method—the cone sets up a swirling motion which breaks up the rust into fine particles.

Bulb made of a PYREX brand glass is a multi-purpose package. First off, since it's immune to thermal shock, it can cope with hot water in circulation, without breaking, even when ambient temperatures hover near zero.

Glass also permits visual inspection for checking water pump and thermostat operation. Moreover, you can see whether you have enough water without taking off the radiator cap.

And, if the motor happens to be so unfortunate as to acquire a cracked block or leaking head gasket, tell-tale gurgles appear in the glass bulb.

Thus, the glass bulb's unique combination of "see-through-ness" plus resistance to temperature changes plus ruggedness make for maximum utility.

A small item, this, but typical of the new products people develop. It's also typical of the design for inexpensive mass production you can expect when you work with Corning engineers.

Even Edison's filament was just a bright idea till he came to Corning to talk about a cover for it. Thus, glass enclosures for ingenious brain-children are a tradition with us.

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PYREX pistol for hot stuff— Sampling molten metal may not sound like a task you'd ordinarily assign glass to. But, the Leco people from out St. Joseph (Mich.) way do.

Their pistol-like contrivance for "shooting" samples of molten metals is fitted out with a barrel made of PYREX tubing. Cock the gun, dip the barrel momentarily into the molten mix, and a sample of the hot stuff is sucked right up into the tube where it solidifies. After that, you break away the "crazed" tubing and subject the metal to whatever tests you wish.

As the Leco engineers have discovered, PYREX tubing is both inexpensive and readily available. A long piece for the barrel of this sampling gun protects the person taking the sample and keeps the sample surface shiny and free of oxidation—a real timesaver compared with older methods of preparing samples for testing.

Actually, we don't ordinarily call attention to the *breakage* applications of PYREX tubing, or for that matter, of any of the other glass products we make.

Forsooth—our usual message speaks, with due modesty, of physical strength, resistance to thermal shock, and over-all ruggedness. And that perhaps points up one of the real virtues and attractions of glass: its ready versatility and adaptability to uses and purposes not even glimmered at first.

Take for another example (from our files of happy customers) the use of expendable glass in plastic molding. Manufacturers of such diverse items as billiard balls, insulators, and catheters have found glass an ideal (well, almost) material for molds. For one thing, glass being nonadhesive, the plastic doesn't stick to the mold. Glass molds cut processing costs, too, since like the metal samples in the Leco gun, plastic products molded in glass come out with a smooth finish.

Which, in a round about way, brings us to say that . . .

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At the risk of repeating ourselves we point with pride to the diversity of aptitudes that we can custom-build into glass at your behest. Be it product or process that's on your mind, there's probably already a glass (maybe even a finished product ready to mass produce) that can meet the chemical, physical, mechanical, electrical, and optical qualities you're looking for—not to mention the compelling beauty of things made of glass.

Good starting point for getting acquainted is our copiously illustrated little primer called "Glass and You." It's a painless introduction to this wonderful world of glass, telling and showing how and why this centuries-old material is the able ally of our mid-20th century technology.

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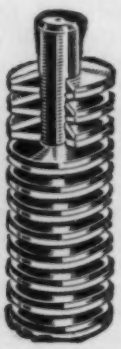

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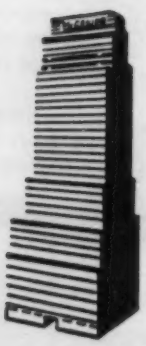

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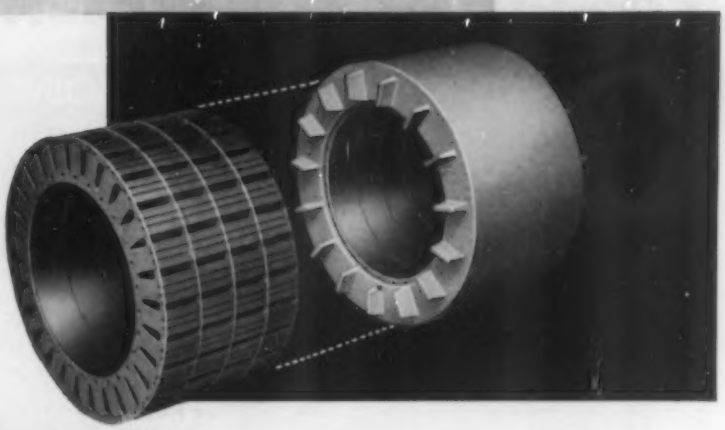

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PROBLEM: The John R. Hollingsworth Corp., Clifton Heights, Pa. had to secure permanent magnets in the rotors of their 12.5KW, 1714 RPM Alternators. Non-machinability of the magnets required their being cast as inserts in aluminum. *But, magnetic properties of magnets are such that the lowest possible temperature has to be maintained during the casting process.*

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RESULTS: In addition to providing a strong, compact mechanical assembly able to withstand high rotational speeds, Rolle's methods improved efficiency of the rotor. Magnetic output has been increased 10% over previous attempts by applying Rolle's advanced techniques, which assure a sound permanent mold casting yet keep insert temperature at an absolute minimum.

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FIGHT WEIGHT WITH STRENGTH

PERTINENT DATA

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Alloy Aluminum 356
Temper As cast
Size 13" O.D. x 9⅞"
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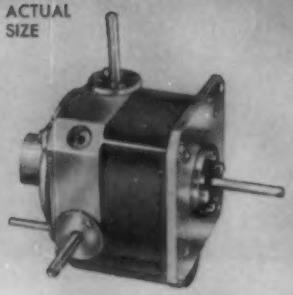

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- ease maintenance
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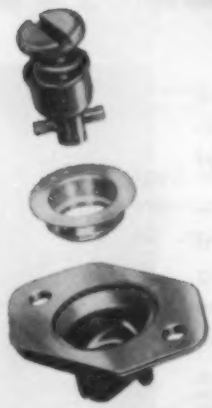

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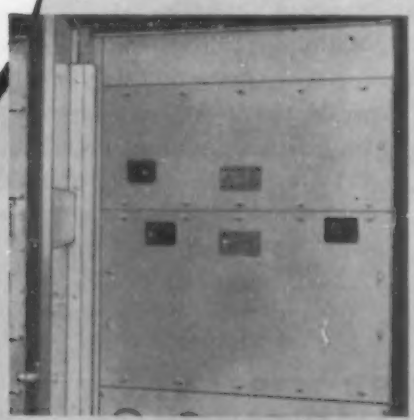

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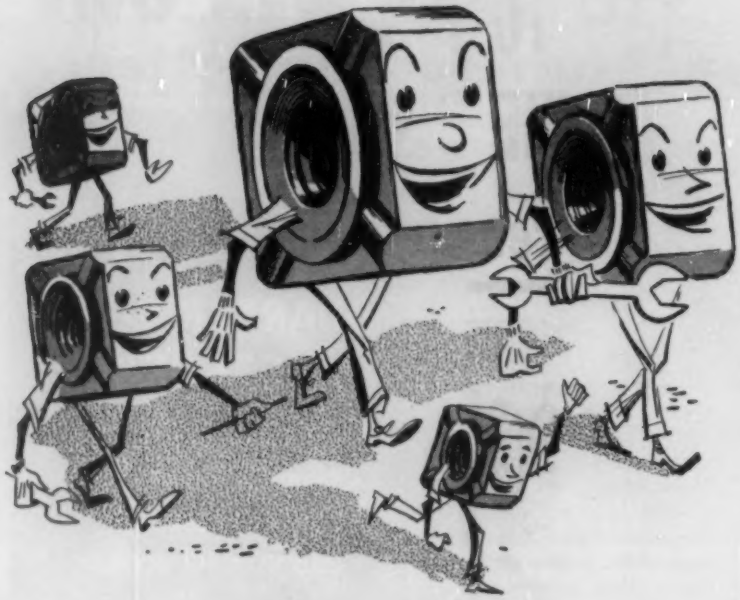

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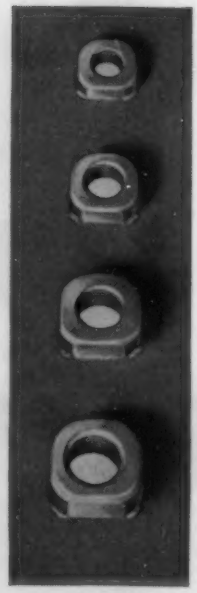

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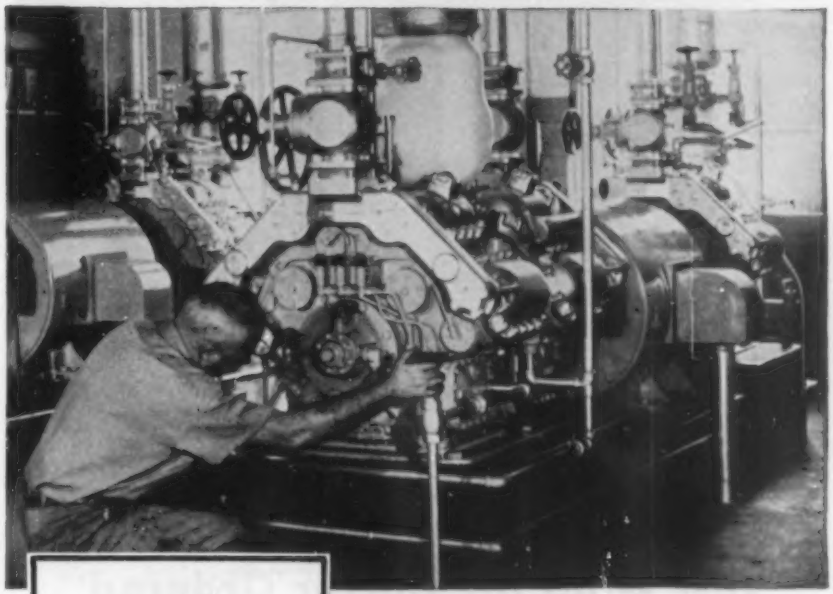

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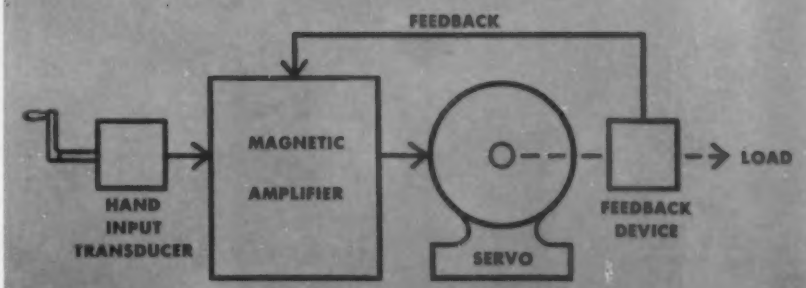

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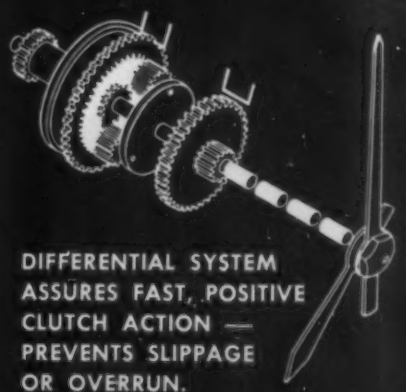

DIFFERENTIAL SYSTEM ASSURES FAST, POSITIVE CLUTCH ACTION — PREVENTS SLIPPAGE OR OVERRUN.

Positive engagement of pawl with gear combined with fine gear teeth provides the instant response necessary for a timing accuracy of ±.01 seconds on the 60-second timer, and ± .005 minutes on the 60-minute unit.

On the dial face, a large sweep hand makes possible fast, exact readings from the outer scale, while an accumulator pointer records larger time units on a separate scale in the center of the dial.

This compact unit is available for AC or DC operation in commercial and military applications. It is used in laboratory experimentation, for testing communications equipment and systems, and in the field of nuclear research, as well as for timing critical industrial processes.

For complete information on the Type 690, write for bulletin PB-610.

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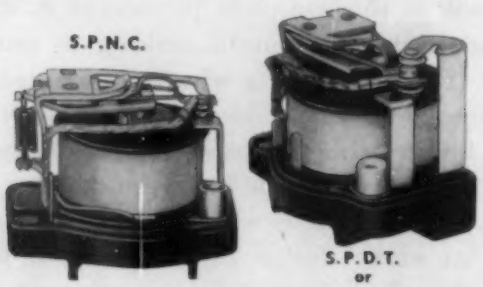

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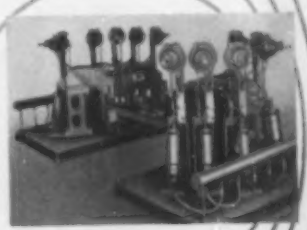

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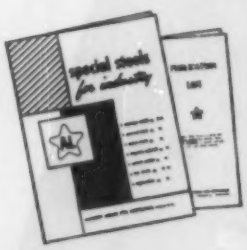

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115—Pneumatic, Hydraulic Components
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